POWER

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"I understand three languages," said an old-time engineer, "German, English and Powerhouse."

"Powerhouse?" we inquired, wondering what he could mean; "what is that?"

"It is the language of engines, generators and pumps, and of boilers and furnaces. And it is learned only after long and studious intimacy with the machines and apparatus that speak it.

"The novice can hardly distinguish one powerhouse sound from another, much less tell what any particular one signifies—he simply hears one confused jumble of noise.

"Not so with the engineer. He knows the soft tune which the contented, well-lubricated generator hums and he knows instantly when that tune changes to a complaint. And, knowing these things, he also knows what to do to stop the complaint.

"Each piece of apparatus speaks in a different dialect.

"The imprisoned steam in the boiler, struggling with persistent and gigantic effort for release, makes but little sound until, by redoubled effort, it forces open the safety valve and gains its release to the free air. Then what a mighty and triumphant roar it does set up!

"The steam pipes, how they chatter and complain when they are forced to drink too much water!

"Then, there is the dialect of the engine. This piece of apparatus is subject to many ills, and for each it has a special cry. The shaft may be loose in the bearings, and boom out a deep protest at each revolution. The crosshead may be truly cross, and make that fact known by its constant clatter. The piston may be loose on the rod, or a ring on the piston itself may be loose. The steam cylinder may suffer from an attack of water. The valves may be seized with a touch of rheumatism brought on by lack of oil. No matter with what physical trouble the engine suffers, it seems to have some sound by which it can make that trouble known.

"Then, there is the chirography—the handwriting—of the various machines. Of late years this has grown to be a most important study, for by it we are enabled to learn much that is valuable about the character and habits of a piece of apparatus.

"Perhaps the oldest and most widely known instrument, by means of which a machine is able to give us a written message, is the steam-engine indicator.

"The diagram that the indicator draws is a truthful diary of what the engine does during a certain time. By means of it the engineer is able to learn much that is important if he has any desire to operate the engine economically.

"The recording steam gage, vacuum gage, wattmeter, water meter, draft gage, CO_2 machine, pyrometer, thermometer, etc., are other devices which enable power-plant apparatus to give us a written message of what they are doing and how.

"The writing made by these instruments is quite simple and easy to read. But the significance of that writing is not always so easy to fathom.

"To successfully understand the spoken and written language of the power house requires experience, thought and study. To be a master of them is worth real money."

Power Plant of the Ayer Mill

By Warren O. Rogers

In designing this power plant every precaution was taken to guard against a shutdown. Labor-saving and safety apparatus is in evidence throughout the plant.

The two 2500-kilowatt turbines are made with a special casing in which valves are so placed that steam can be taken from the second stage and used for heating water in the mill.

When the American Woolen Company decided to erect another mill upon the plot near its Wood mill at Lawrence, Mass., it was at first proposed to drive it electrically from the power plant of that mill. A woolen mill, however, has a great deal of use for low-pressure steam, and the cheapest known way to produce power is by the use of a steam engine or turbine as a reducing valve between a high- and low-pressure steam system. Incidentally it may be said that it takes as many boilers to supply steam for heating the water used in the dye house and in the manufacturing processes at the Ayer mill as it does to run the turbines at their rated capacity while steam is being taken from their second stages for heating the same amount of water.

Because of this, and of the impracticability of bringing steam from the Wood mill for use in the dyeing and finishing departments, it was very desirable that the Ayer mill, as the new structure is called, should have its own power plant. After a study of the conditions Charles T. Main, the designing engineer, decided that he could get an adequate plant upon the limited ground space available. This involved the use of water-tube boilers and turbine-driven generators as they are more compact in plan than horizontal tubulars and piston engines. It also involved the use of overhead coal storage with its attendant coal-conveying machinery, and this again pointed to the use of mechanical stokers. The result has been that the installation is of the most advanced and elaborate sort in which none of the newer type of power apparatus and appliances is lacking. In this respect it is the antithesis of the Wood mill plant erected some five years ago and an excellent opportunity is afforded to compare the cost of power production in these two extreme types of plant.

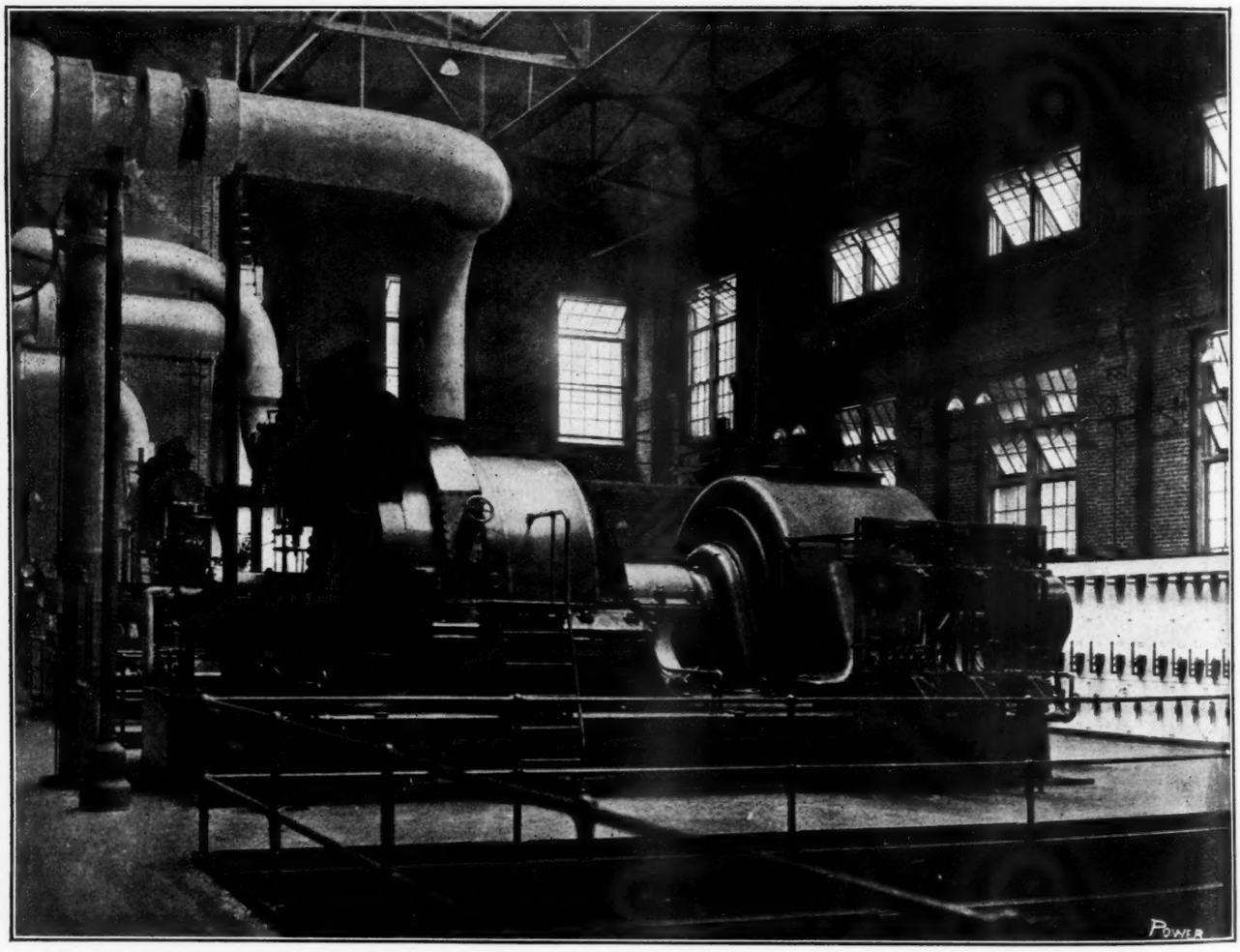


FIG. 1. TWO 2500-KILOWATT STEAM TURBINES FITTED WITH SPECIAL GATE VALVES IN THE TOP CASING OF THE SECOND STAGE

TURBINES

In the turbine room there are two five-stage horizontal Curtis turbines, each of 2500 kilowatts capacity, and there is room for one more of the same size. They run at a speed of 1200 revolutions per minute with a steam pressure of 175 pounds. The steam valves are hydraulically operated by means of oil under a pres-

sure of 80 pounds per square inch, the oil pressure to the bearing being maintained at 20 pounds.

In Fig. 2 is shown a sectional view of one of the turbines. Both are fitted with specially designed upper casings in which are arranged gate valves opening to the second stage. Through these valves steam is taken from the turbine at a pressure of between 6 and 7 pounds and is delivered to the dye house through a 14-inch pipe; the exhaust from the auxiliary turbines in the basement is also discharged into this main. The exhaust pipes of the two main turbine units connect with a 30-inch spiral-riveted atmospheric exhaust pipe, each fitted with an automatic relief valve. Both turbines are supplied with steam through either of the two 10-inch steam mains. The condenser turbines are of 90 horsepower each.

There has been added to the original design a filtering system through which all the water from the condensers is passed. The filter consists of a concrete basin with a system of collecting pipes with brass nozzles buried under sand and quartz. There is also in the filtering well a heating pipe supplied with steam through a reducing valve from the high-pressure system in order to supply hot water to the dye house when the turbines are not running. It requires an 8-inch pipe to supply enough live steam at a reduced pressure of 10 pounds to heat the water used in the dye house and the slasher room.

Two 12-inch rotary pumps circulate the water from the filter to the dye house, each being capable of delivering 3600 gallons per minute when

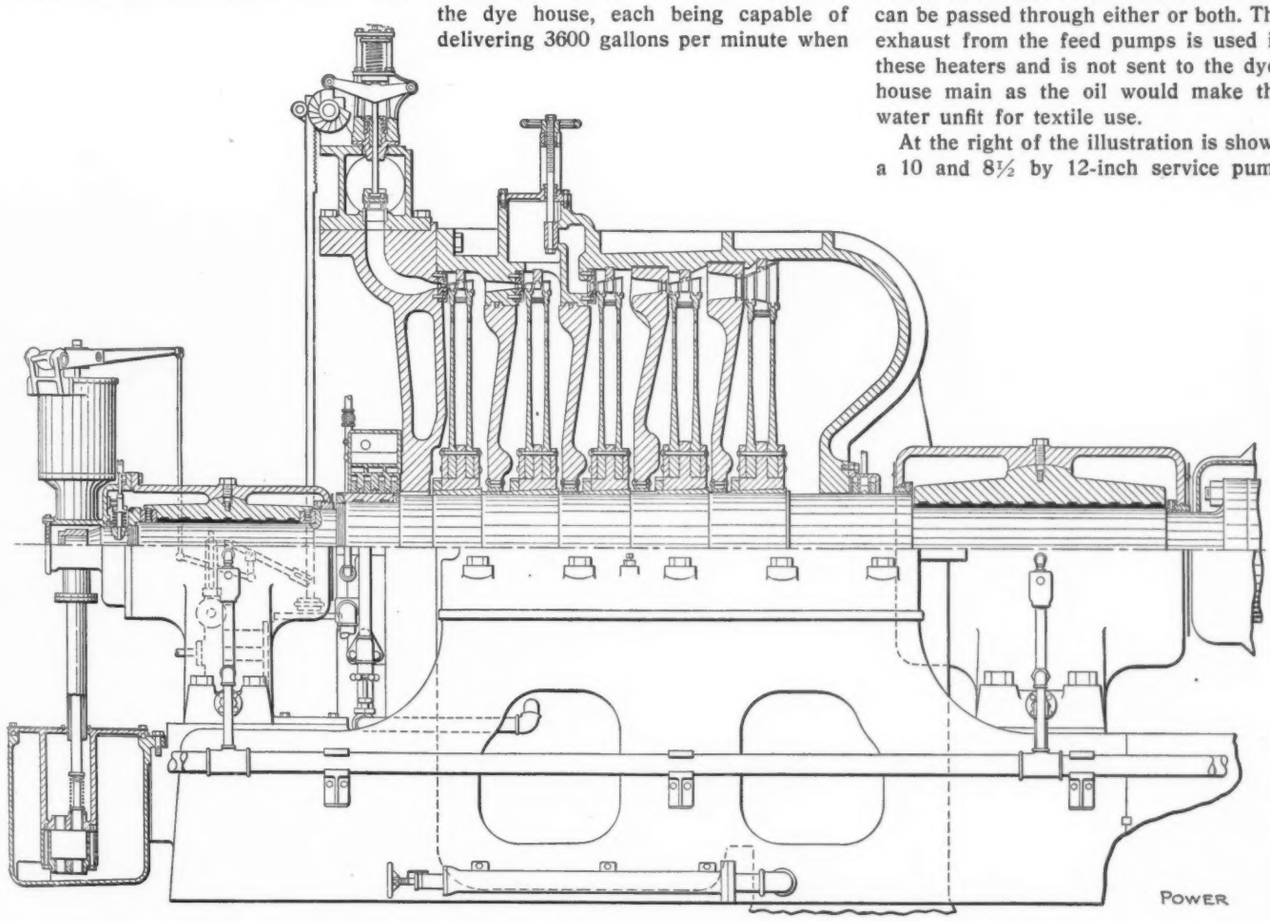


FIG. 2. SECTIONAL VIEW OF ONE OF THE FIVE-STAGE TURBINES, SHOWING VALVE IN SPECIAL CASING

pipe leading to the dye-house main is fitted with an atmospheric exhaust valve which discharges into a spiral-riveted exhaust pipe with an exhaust head.

Each turbine exhausts into a separate LeBlanc condenser which discharges the condensed steam and condensing water into a hotwell at a temperature of 105 degrees. A vacuum of but 27 inches is maintained with this temperature of discharge water as a high hotwell temperature is more economical and of greater importance than a higher vacuum. The

running at a speed of 1500 revolutions; each is driven by a 150-horsepower steam turbine, and one is held as a reserve unit.

PUMPS

All other pumps are located in a basement pump room which runs the entire length of the power plant, as shown in Fig. 3. Beginning at the left hand of the illustration, there are three 12 and 7 by 12-inch boiler-feed pumps which take the feed water from a hotwell, and after it is forced through one of two heaters and an economizer it is delivered to the boilers through a 5-inch Venturi meter. The boiler-feed pumps are equipped with pump governors. There are two 6-inch feed lines running from the pumps to the economizers and two feed lines are continued over the boilers having valves so arranged that in case one line gives trouble the other can be used. The feed pumps have three sources of supply, the one most used being a 12-inch cast-iron pipe running to the hotwell. The pipe is reduced to 10 and 8 inches at the two end pumps respectively. The other two suction lines are of 6-inch and 10-inch cast-iron pipes; one is connected to the city water main and the other to the canal penstock.

The two feed-water heaters are connected in tandem so that the feed water can be passed through either or both. The exhaust from the feed pumps is used in these heaters and is not sent to the dye-house main as the oil would make the water unfit for textile use.

At the right of the illustration is shown a 10 and 8½ by 12-inch service pump which is connected to the sprinkler system. This pump is also piped so that its discharge can be used for feeding the boilers. A 10x8½-inch service pump supplies water for washing purposes and there is a two-stage centrifugal pump direct-coupled to a high-speed steam engine running at a speed of 350 revolutions per minute which is used in the winter only and circulates hot water for heating purposes through the heating system. The circulating water is heated in a closed heater and after making the circuit of the

system it returns to the heater with a drop of about 10 degrees in temperature. There is also a single-stage pump driven by a 50-kilowatt induction motor which is used as a reserve unit for the heating system.

All of the water removed from the heater connected to the heating system is taken care of by a 7 and 4½ by 10-inch outside-packed pump, which sends the water from the heater direct to the boilers through an independent feed pipe.

A small air compressor, the steam end of which is 10x10 inches, supplies air for factory use, blowing motors, etc.; the air end has a 12x10-inch cylinder.

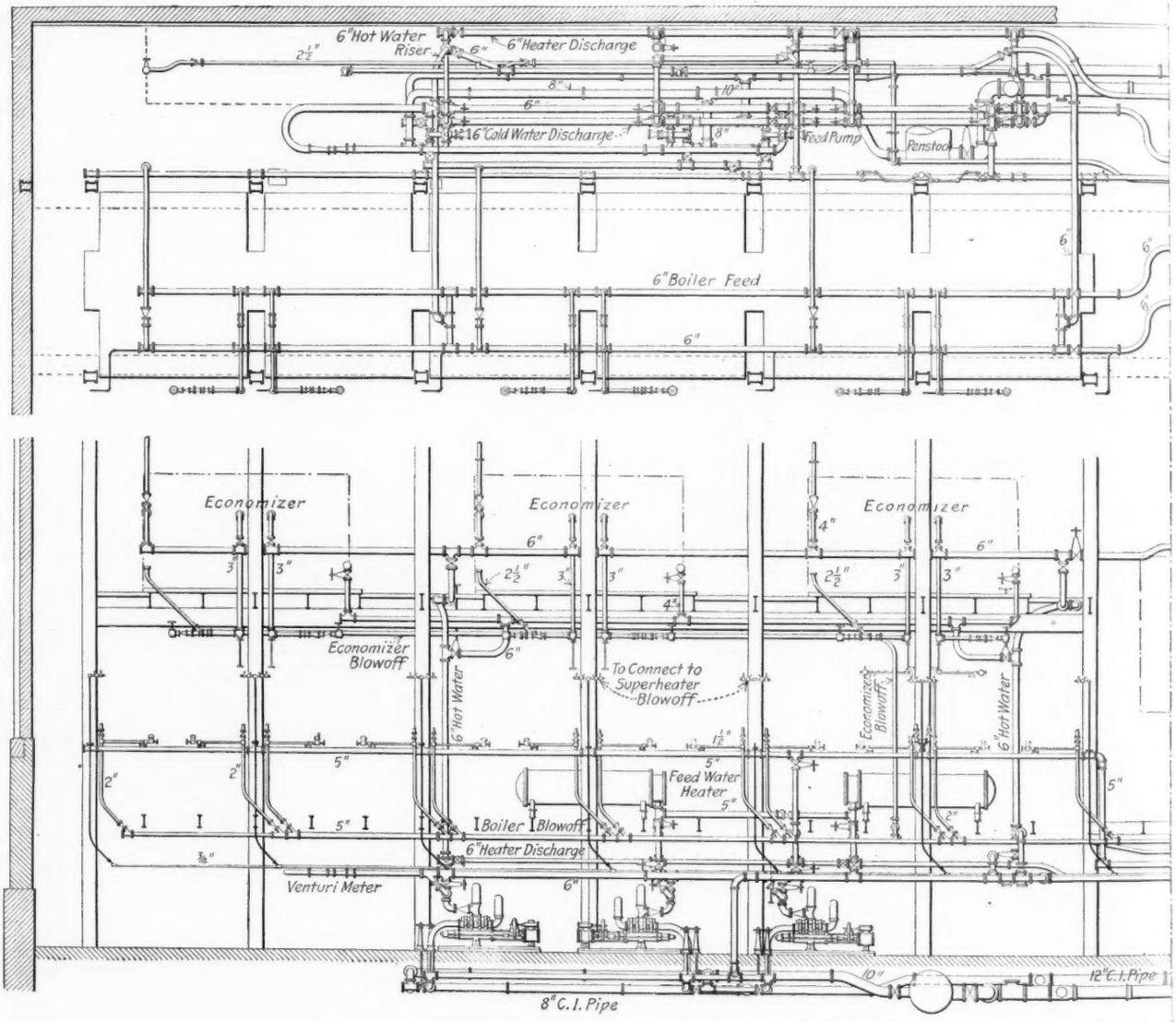


FIG. 3. PIPING OF WATER-SUPPLY, BOILER

PIPING

In Figs. 4 and 5 are shown a plan and elevation of the steam and exhaust piping of the plant. The three boiler-feed pumps exhaust into a 10-inch pipe which is connected to both of the feed-water heaters. The main-pump exhaust line is reduced to 5 inches at the far end. The steam and exhaust pipes are suspended from the basement ceiling, and to facilitate opening and closing the larger valves the valve stems have been fitted with sprocket wheels and chains, the latter coming within reach from the floor. This idea is carried out on the main stop valve on the steam pipes which are connected to the second stage of the turbines.

There are two auxiliary lines of steam headers, one 6 inches and one 10 inches in diameter. The exhaust steam from the auxiliary turbines is carried through a 14-inch pipe to the feed-water heaters which are set on the boiler-room floor back of the boilers. An examination of the piping plan shows that practically every possible avenue has been closed against a shutdown due to pipe-line failure.

The manner in which the heavy steam and exhaust pipes are supported is interesting. In Fig. 6 are shown the spring supports of the 30-inch exhaust pipe. Heavy brackets are fastened to the wall by 1¼-inch expansion bolts. A steel casting is secured to the exhaust pipe above the brackets and fits a second steel casting which is bolted to the first. Two bolts, each 1½ inches in diameter at both ends and 2 inches in diameter for a distance of 8 inches below the steel casting, are used as shown. On the large portion of the bolt an adjusting nut and jamb nut are screwed. A cast-iron washer comes next, followed by a ⅞-inch round steel spring having when free a pitch of 1¾ inches and an outside diameter of 5 inches. Each of these bolts fits in a saddle which rests on the brackets; the springs rest in a seat in the saddle. The nuts are so adjusted that the weight of the exhaust pipe is carried by the springs. This removes undue strains from the lower portion of the exhaust pipe and its connection to the condenser.

An altogether different arrangement has been used in connection with the counterbalancing device on the two 10-

inch steam mains and on the 14-inch exhaust pipe. Referring to Fig. 7, the lower steam pipe is clamped by a ⅝x3-inch sectional band having two ⅞-inch side rods bolted to a channel bar above the upper steam pipe. A 1¼-inch rod is also bolted to the channel bar and is fitted with a turnbuckle at the upper end; the turnbuckle is bolted to a steel lever on which counterweights are placed, each weighing about 54 pounds. The lever is pivoted on a steel pin driven in the lever and seats on a steel-bearing plate; this plate is driven into a slot in the bracket secured to the brick wall by five 1-inch expansion bolts.

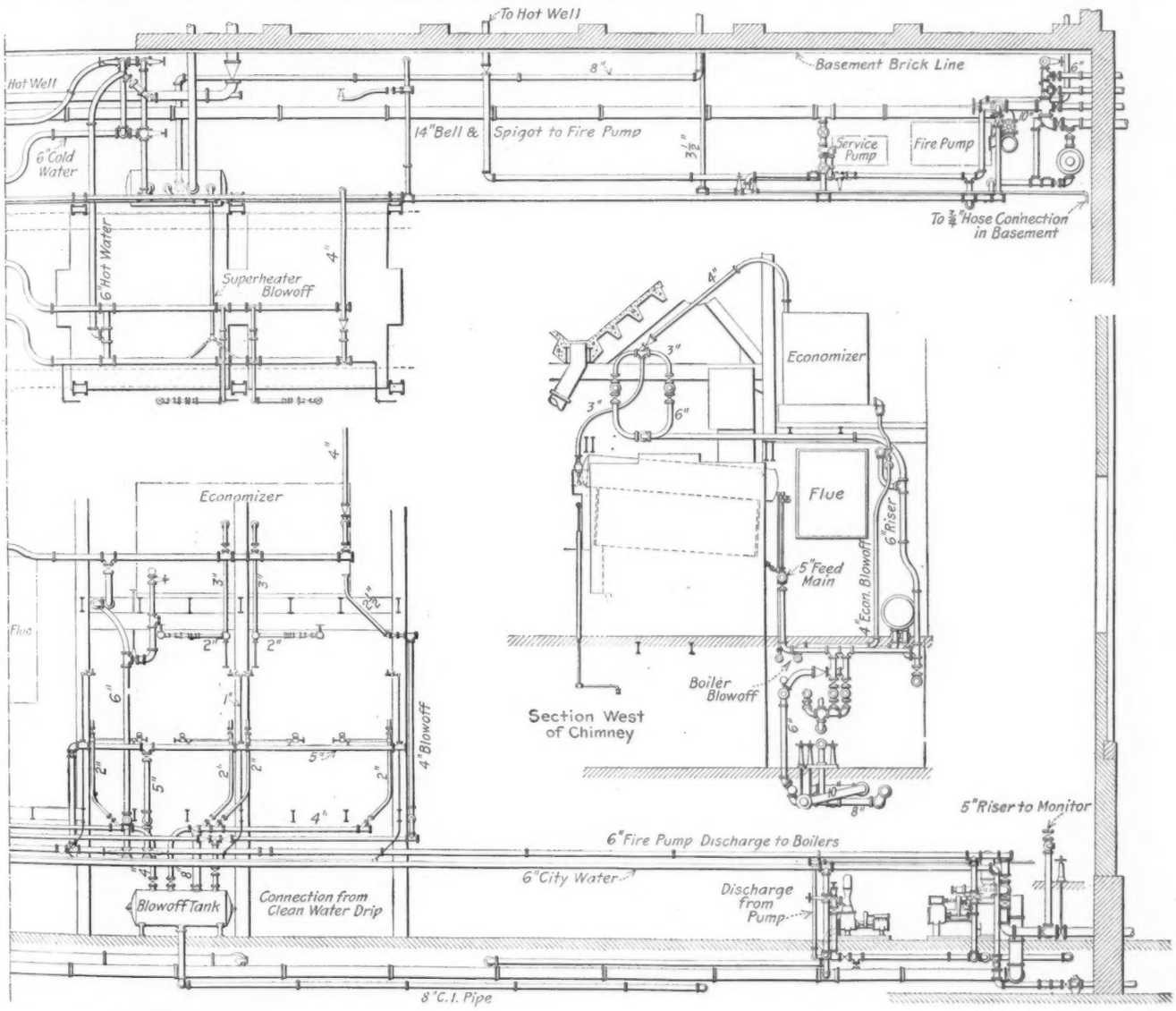
The upper pipe is fitted with a sectional ring which is bolted to a single 1¼-inch rod with a turnbuckle at the other end and is attached to the counterweight arm, as shown. A similar arrangement has been provided for the 14-inch exhaust pipe, as is shown in Fig. 8. In this instance the counterbalance lever is forked, and besides being fitted with a steel pivoting post at the bracket a similar pin is driven in at the short end and supports the links, each of which is connected by a ⅞-inch rod to the flange of the pipe. The general arrangement is shown in the illustration.

Boilers

There are eight 600-horsepower Heine boilers with Murphy mechanical stokers, each 8 feet deep and 12 feet wide, the largest stokers made by this manufacturer. Two engines drive the stokers on six of these boilers and one engine drives the stokers for the other two boilers.

In Fig. 9 is shown a view of the boiler room. The furnaces are of the dutch-oven design and are supplied with coal from above. Space has been reserved for four additional boilers at the far end of the row.

Owing to the size and as a matter of convenience, these boilers were assembled bottom-side up from the usual position. This enabled the workmen more freedom than if the riveting of the headers to the steam drum and the rolling of the tubes were done from below. After the boilers were assembled they were turned over, thus bringing the steam drums on top and the boilers blocked up ready for the brick setting to be put in place. Each boiler is equipped with a Foster superheater which superheats the steam 125 degrees. There are four economizers, one for each set of two boilers. The furnace gases can be bypassed to the brick stack, which has an internal diameter of 12 feet and is 265 feet high. The draft is ⅛ inch over the fires.



Feed and Blowoff System

Coal and Ash Conveyers

Above the boilers is located a 5000-ton coal pocket which is divided in the center by an ash bunker. Coal is discharged from the coal cars on the track outside of the boiler room to a crusher which delivers it to a bucket conveyer which in turn deposits the coal on a belt conveyer running over the coal

pocket. Coal is taken from the pocket into a traveling weigh hopper and is distributed to the various stokers.

A vacuum conveyer handles the ashes from beneath the stokers as well as soot from the economizer and conveys them all through a 6-inch pipe to the ash bunker located above the boilers. The ashes from the ashpit are hoed into an opening of the vacuum system through a rear outlet and the soot from the economizers is hoed out into connections leading to the vacuum system. Ashes from the ash bin can be delivered to cars on a track on the outside of the building or loaded into carts and carried away. The arrangement of the ash and coal bunkers, ash-conveyer system and elevation of the boiler and turbine rooms are shown in Fig. 10.

The ash bunker, which is some 50 feet across and constructed of reinforced concrete, is tight enough to allow a vacuum of 14 inches of water to be maintained in it. A rotary exhauster driven by a 35-horsepower motor is used for this purpose.

Electrical Units

In the turbine room there are three exciter units which serve the two 2500-

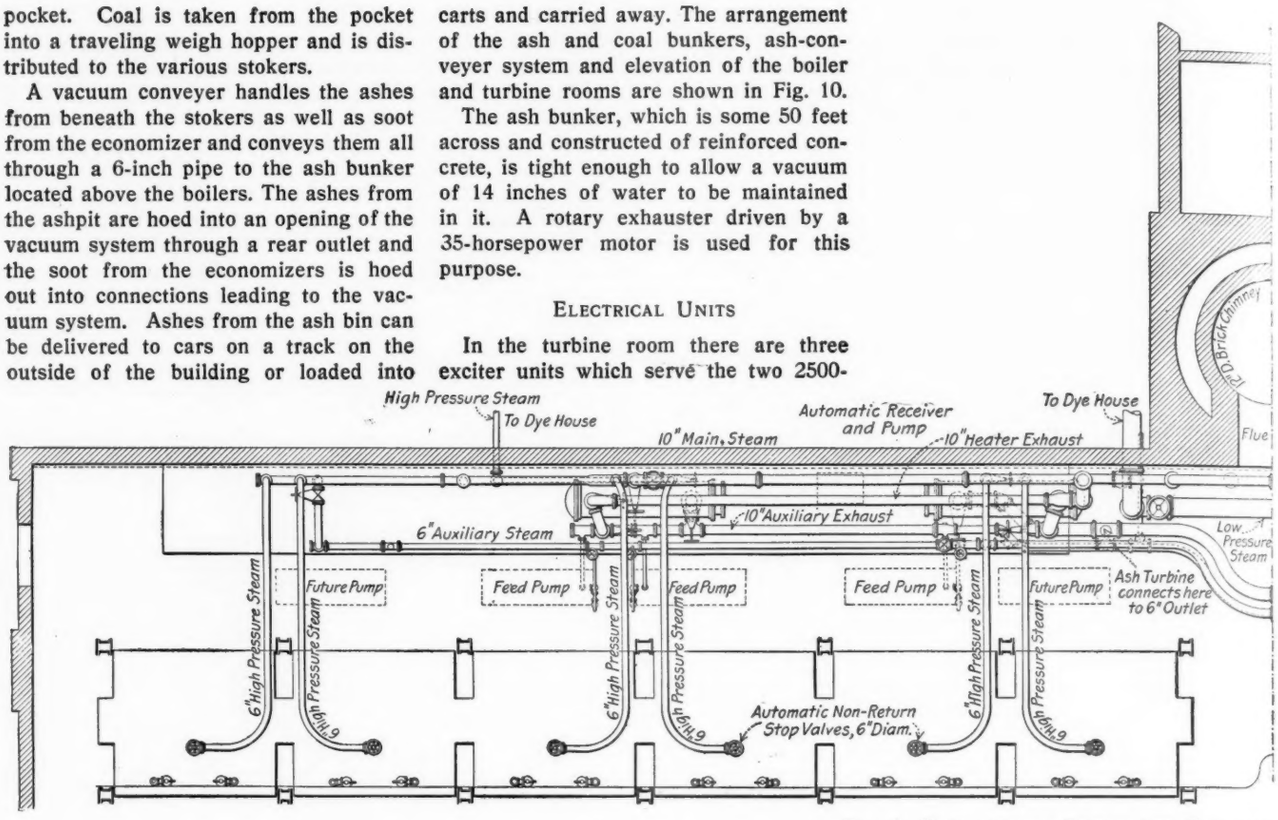


Fig. 4. Plan of the Steam and Exhaust

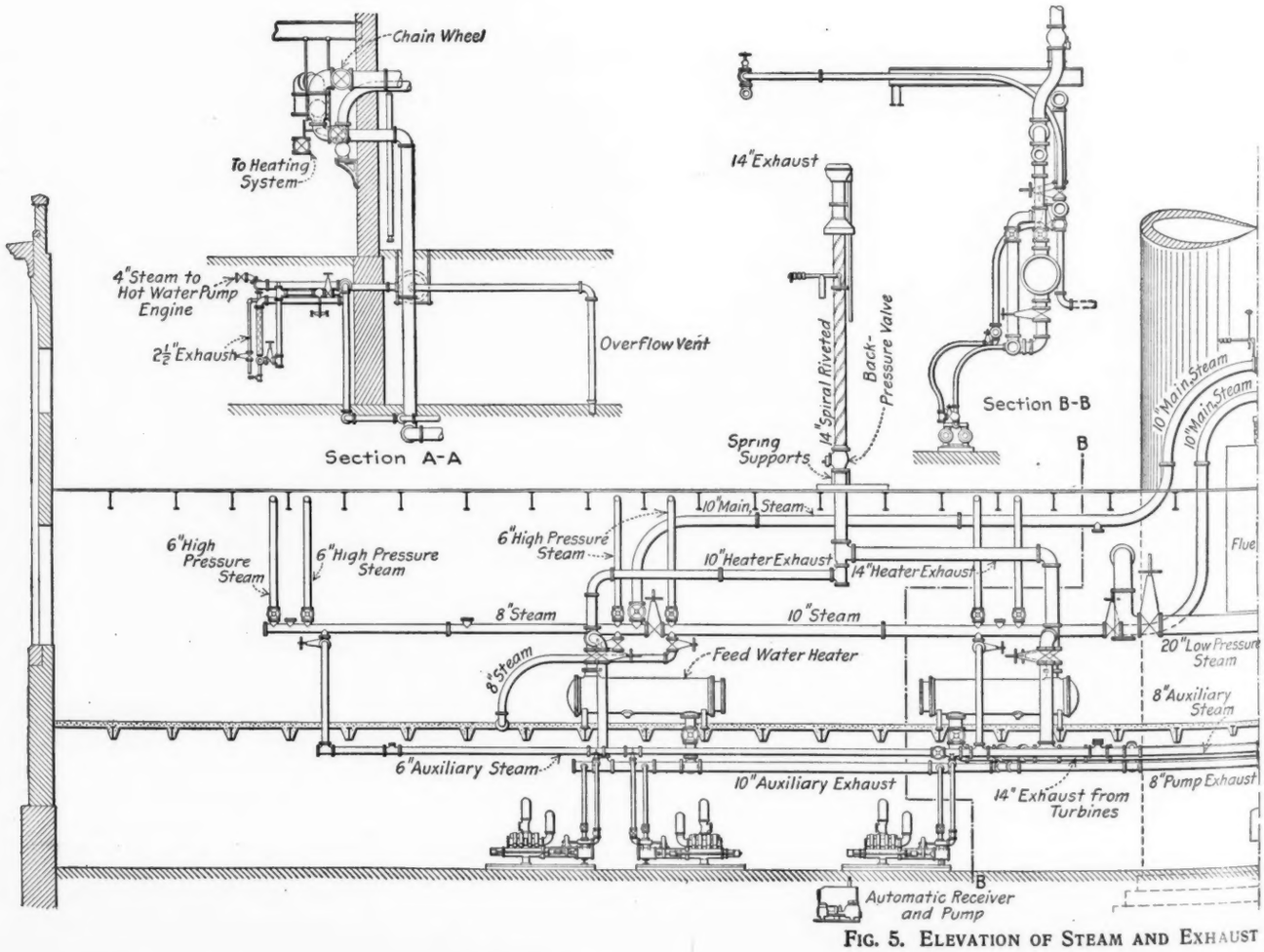
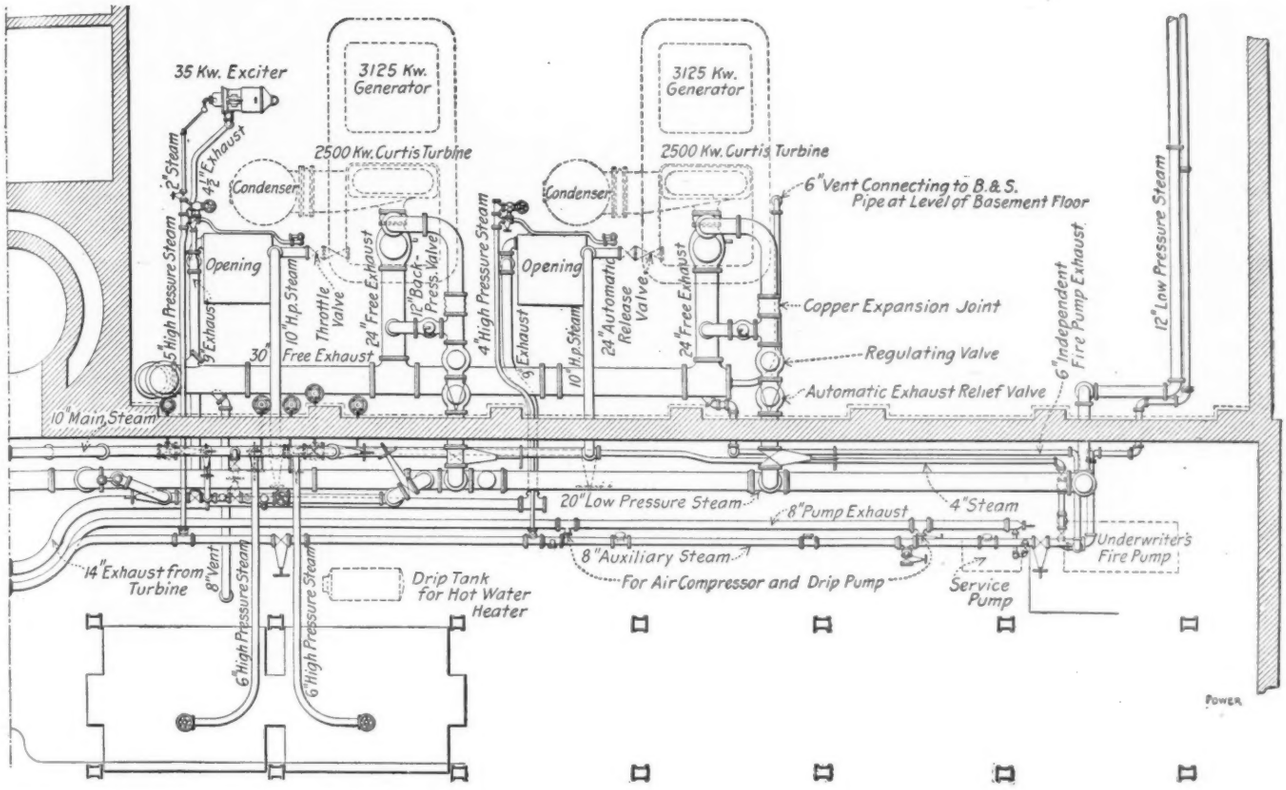
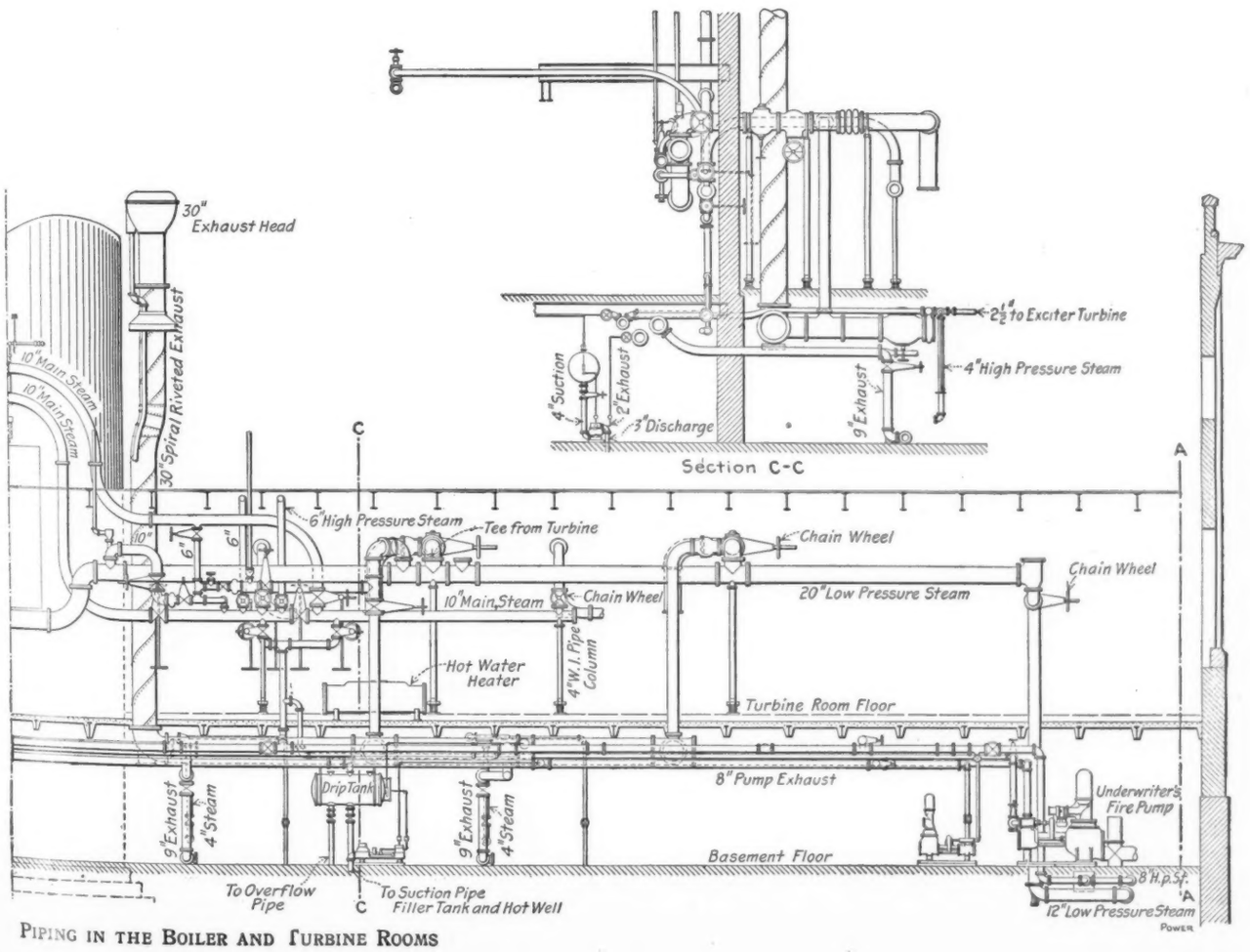


Fig. 5. Elevation of Steam and Exhaust



PIPING IN THE TURBINE AND BOILER ROOMS



PIPING IN THE BOILER AND TURBINE ROOMS

kilowatt alternators. Two of these units are each driven by a 60-horsepower induction motor and the third is driven by a small steam turbine. Their voltage is 125.

At one side of the turbine room is the switchboard of the plant. The main generator switches and circuit-breakers are mounted upon a framework at the side of each generator, as shown in Fig. 1. The switchboard proper carries the necessary recording instruments and switches for the lighting and motor circuits leading to the mill. Above each switch is a card which designates the circuit and the motor load carried on the circuit.

Back of the panels are located the bus-bars and cable connections, the latter dropping to the basement and running to the mill upon cable racks. These racks are constructed of angle irons to which wooden crosspieces are attached. The cables are clamped to these wooden crosspieces.

A noticeable feature of this plant is that nothing has been crowded into an inaccessible place and the plant is light, roomy and well ventilated. There are few, if any, industrial power plants which are equipped with so many precautions against a shutdown or are fitted with so many labor-saving and safety appliances and so many means for keeping track of performance. There are at least a dozen recording gages about the plant for different purposes, provision is made for weighing the coal and metering the water to each boiler, and it is to be hoped that some interesting data upon actual power-plant results will be evolved.

Sequel of Rochester Mud Drum Explosion

Brief mention was made in the July 26, 1910, issue of the cast-iron mud-drum explosion at one of the power houses of the Rochester Railway and Light Company, Rochester, N. Y., on July 16, 1910, in which the boiler was wrecked, one man killed and two injured. The cast-iron mud drum was in one of eight Cahall boilers installed in 1901.

On the morning of the accident and about two hours prior thereto, the pressure exceeded 170 pounds, the boilers being allowed 175 pounds by the Fidelity and Casualty Company. The fires under the boiler had been banked about half an hour before the accident; fresh coal had been put on and feed water at a lower temperature than the water in the boiler was injected; the chimney damper had been closed, confining the gases. Just before the explosion a fireman observed smoke and flame issuing from the front of the boiler near the stokers and was trying to open the

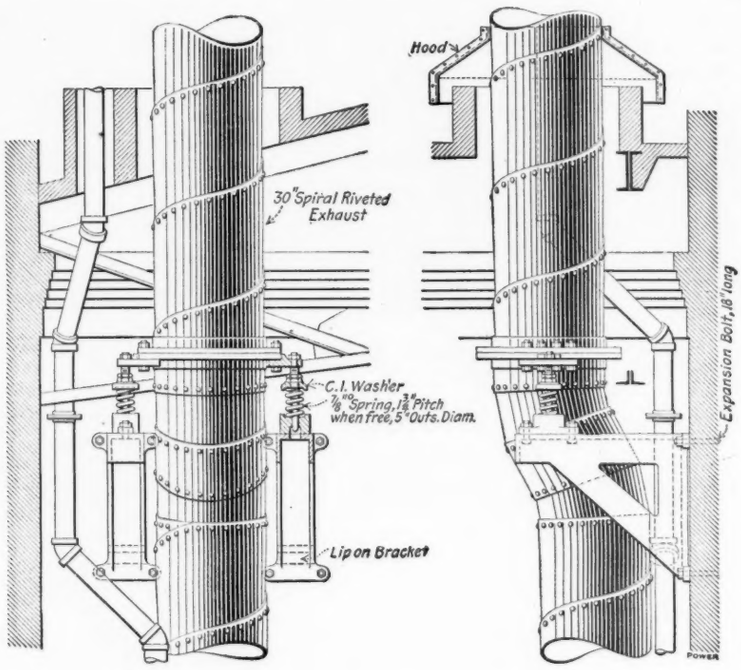


FIG. 6. SPRING SUPPORT FOR 30-INCH EXHAUST PIPE

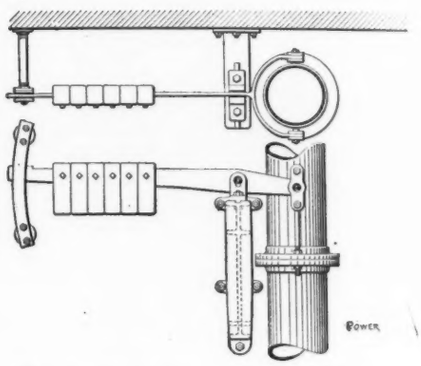


FIG. 8. COUNTERBALANCE ON 14-INCH PIPE

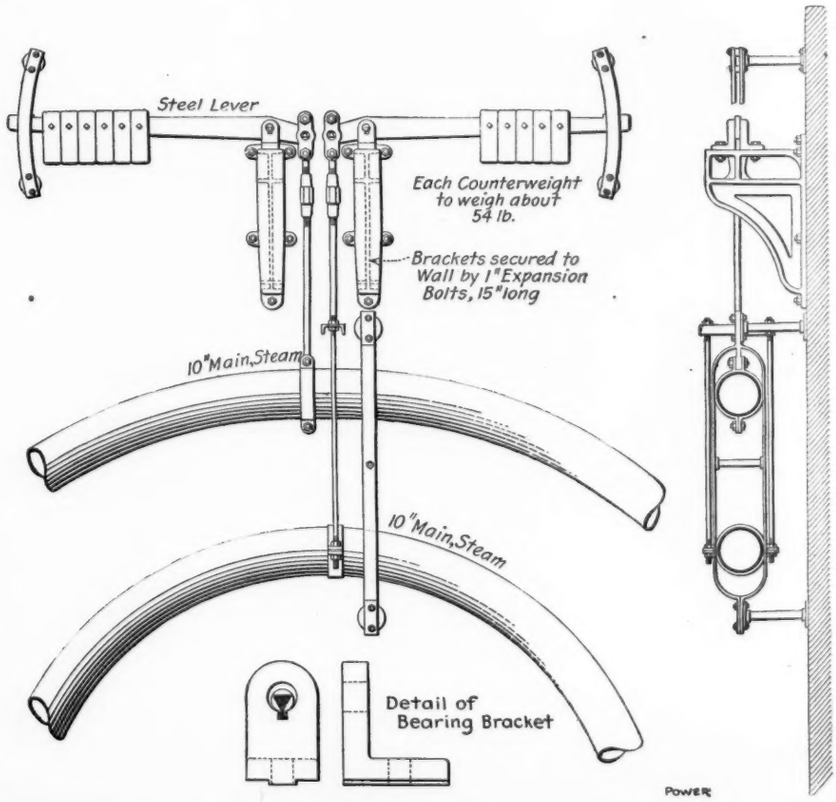

Steel Lever
Each Counterweight to weigh about 54 lb.
Brackets secured to Wall by 1" Expansion Bolts, 15" long
10" Main Steam
10" Main Steam
Detail of Bearing Bracket
POWER

FIG. 7. COUNTERBALANCE ON 10-INCH STEAM PIPE

damper when the explosion occurred. At the time of the accident the pressure was 168 pounds, as shown on the gage, or 175 pounds on the mud drum, due to the weight of the water.

Suit was brought by the heirs of Frank E. Quirk, the man killed, and the Supreme Court of Monroe county awarded damages in the sum of $10,000. An abstract of the finding by the jury is given herewith.

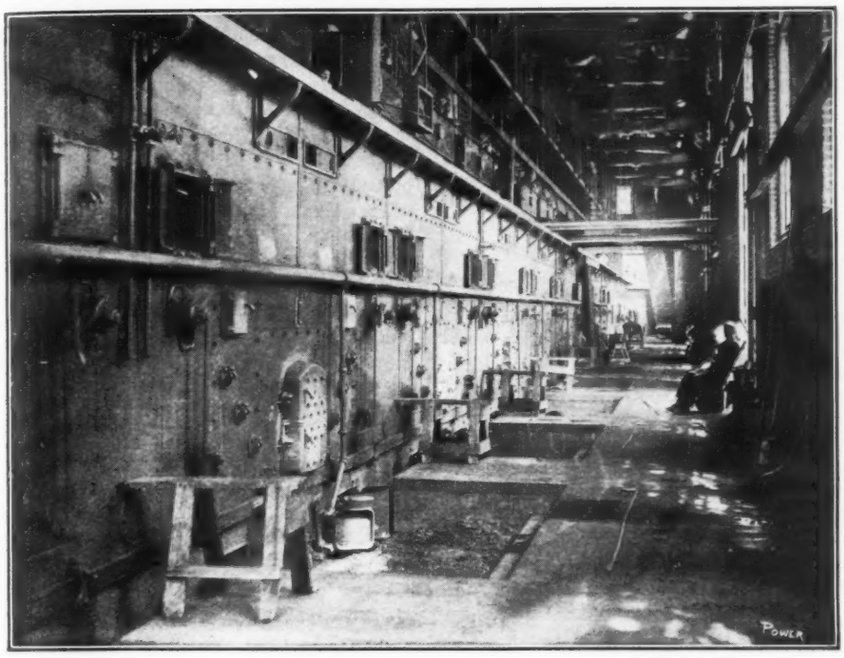


FIG. 9. BOILER ROOM WHICH CONTAINS EIGHT 600-HORSEPOWER WATER TUBE BOILERS

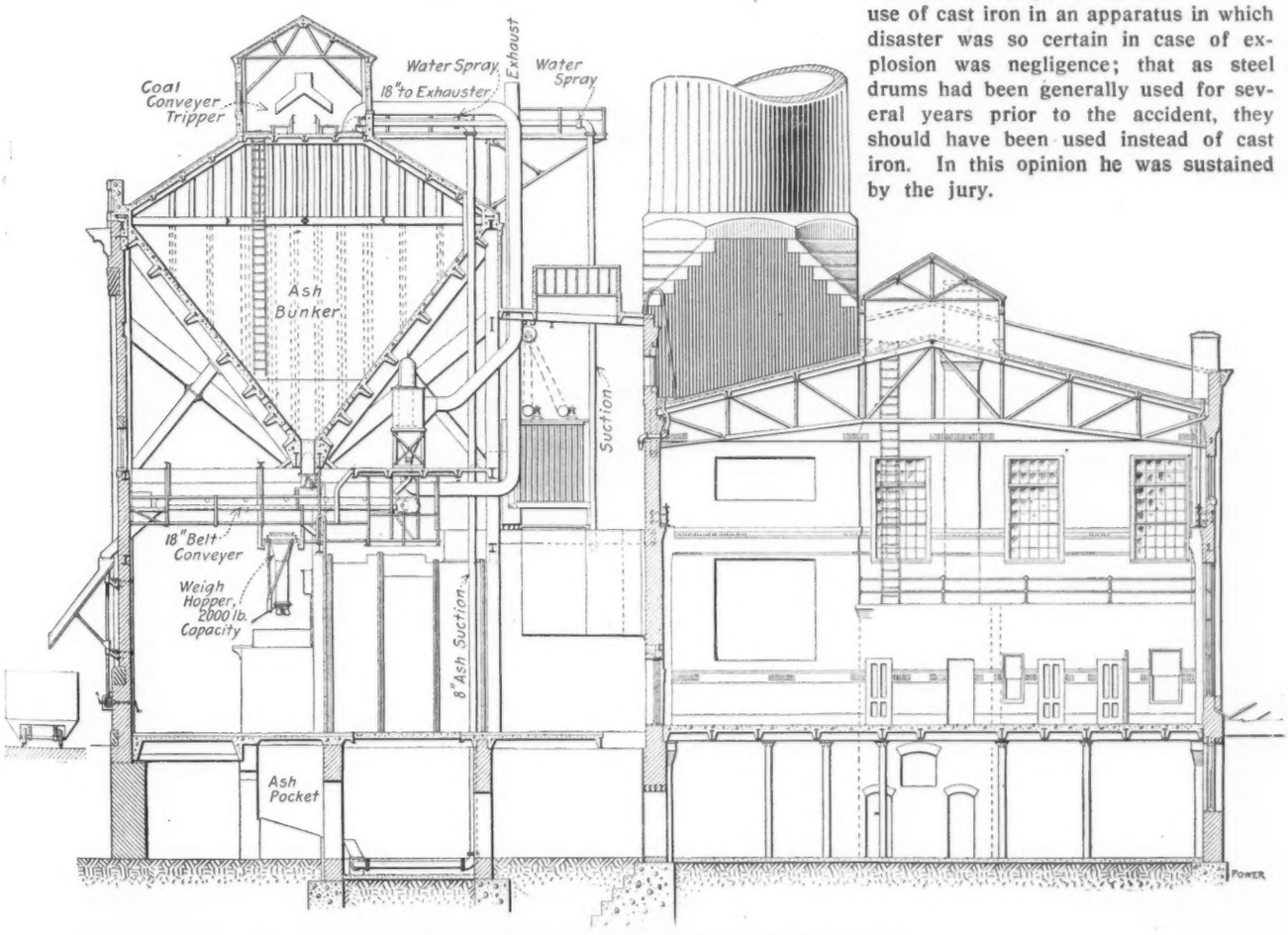


FIG. 10. CROSS-SECTION OF THE POWER PLANT

In the jury's opinion, a cast-iron mud drum was not reasonably safe in a boiler having 168 pounds pressure and its use was negligent. It further appeared that the usual inspection revealed no defects in the mud drum; that it was kept in repair and sustained pressures of from 120 to about 183 pounds, which would be from 126 to 190 pounds on the mud drum. The safety valve was set to blow at 165 to 170 pounds.

The defense contended that the boiler was bought from a reputable maker and that there were many others of its type in use at even higher pressures.

On behalf of the plaintiff, Prof. R. C. Carpenter, of Cornell University, testified as to the unreliability and brittleness of cast iron. He said there were sometimes defects in castings which could not be discovered by any test usually applied by boiler inspectors or, in fact, by any test which would not destroy the drum. Professor Carpenter did not condemn the use of cast iron in steam fittings except in large parts, such as mud drums, as they are subject to the varying conditions of strain and temperature of the gases of the furnace.

Several inspectors testified as to the uselessness of the hammer test for cast iron, and that the hydrostatic test might reveal defects, but it was not sure.

Professor Carpenter claimed that the use of cast iron in an apparatus in which disaster was so certain in case of explosion was negligence; that as steel drums had been generally used for several years prior to the accident, they should have been used instead of cast iron. In this opinion he was sustained by the jury.

Erecting a Large Engine Flywheel

By F. C. Holly

Specific directions, with illustrations, upon how to unload and erect a flywheel.

This information is adapted especially to the engineer who is frequently confronted with this task without having any special appliances for performing it.

In the engine shop the handling of large castings presents no special difficulties as every facility for the purpose is at hand. There are, perhaps, many mechanics who have given no thought to the ways and means that would be employed for unloading, moving and placing the parts of an engine in their final position. Likewise many men having to do with engines would go about the work of removing or replacing heavy parts very awkwardly, if they were suddenly confronted with the necessity.

Yet this is a task which is more than apt to fall to the lot of any mechanic or engineer, although the loading of a bulky and unwieldy casting onto the "boat" and running it on rollers and skids from the car to the foundation, looks simple and easy when the well trained erector is doing it.

Where Conditions Become Difficult

Consider a medium-sized Corliss engine having an 18x3-foot flywheel made in two segments. This sized wheel is usually shipped on a flat car with the two halves standing side by side and separated by distance pieces and clamped together by bolts. Given a good set of appliances, how many operating engineers could tackle the job of unloading and erecting this wheel in full confidence and in a reasonable length of time without delays or mishaps. But given one or two screwjacks of different lengths, a decrepit crowbar, a sledge hammer and a set of rope falls, some old rope and the choice of the best out of a pile of old misfit lumber, some engineers would get "cold feet" before starting. Yet these are by no means uncommon conditions which the erector is obliged to face.

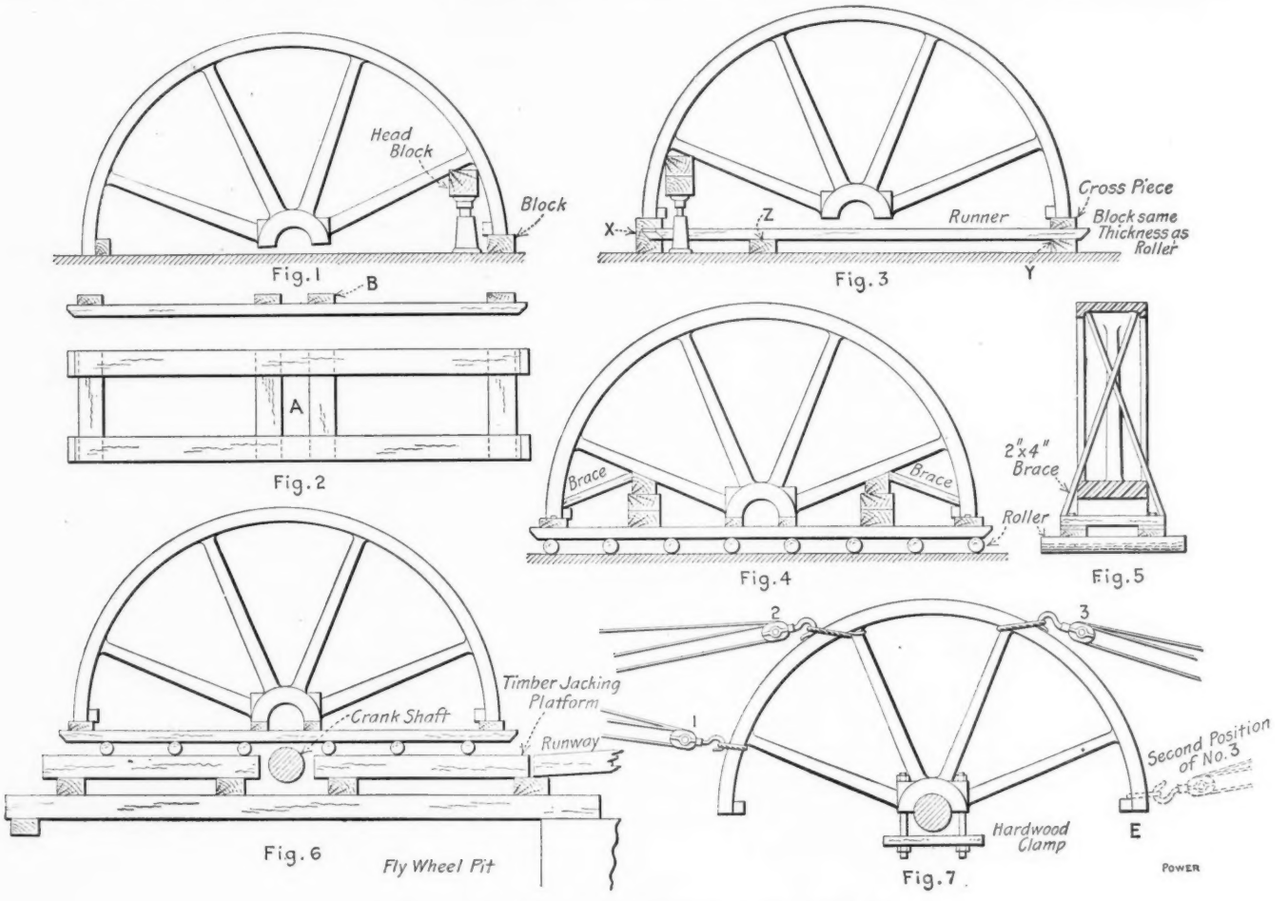
Some Wise Precautions

In loading a segment upon the "boat" or skids, care must be taken not to overturn it. To prevent this it is a wise precaution to keep a guy line on each side while raising. Jacks should be set as in Fig. 1; the head block being hewn in the center to fit the spoke and a jack placed under each end, raising evenly one end of the wheel at a time and following up carefully with safety blocks.

The "boat" can be made of 3x12- or 4x12-inch planks or any wide timber which may be on hand, 19 feet long and 4½ feet wide, laid together with four crosspieces, as shown in Fig. 2, but not fastened until later.

The safest manner of inserting the long "boat" skids under the wheel is shown in Fig. 3. The wheel should be raised and blocked to a hight equal to the thickness of the boat *B*, Fig. 2, plus the diameter of the rollers. Use the long runners and a crosspiece for blocking at one end, as shown in Fig. 3, allowing the other ends of the runners to swing out clear of the block, which should be no longer than the width of the pulley rim.

With the jacks as shown, the wheel



FIGS. 1 TO 7. VARIOUS STAGES IN ERECTING FLYWHEEL

may be raised and the block *X* turned around parallel with the runners and left there for safety. With a sledge hammer the runners can now be driven under the wheel at this end. A crosspiece and roller should be made ready, and as block *X* is drawn out of the way the crosspiece and roller should be inserted. The wheel should at no time be allowed to rest upon the jacks without being blocked.

Block *Z* can now be removed and as many more rollers inserted under this end as will go. The rollers should be chalked and the center crosspieces put in, after which the jacks can be lowered, the other end of the wheel raised, block *Y* removed and the rollers placed.

Handling the Loaded Wheel

The loaded wheel is shown in Fig. 4. With very heavy wheels it may be necessary to have blocking halfway between the rim and hub, as shown. The end crosspieces should now be secured to the runners with one lagscrew in each end. If the wheel is flanged, a safe bracing should be employed to prevent upsetting, as shown in Fig. 5. Another method is to brace from the edge of the "boat" to the center spoke on a six-spoke wheel.

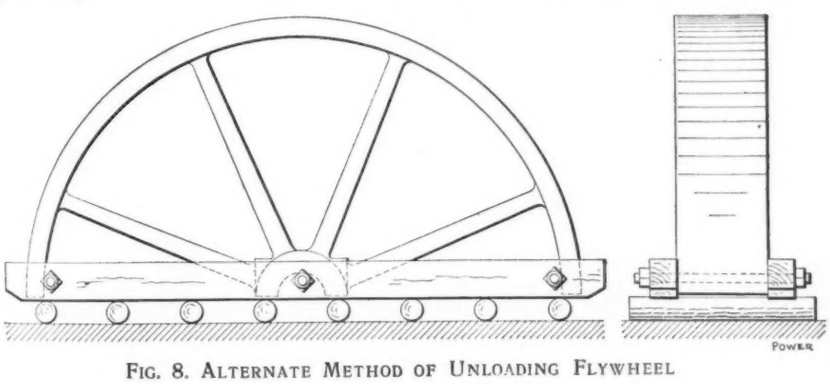


Fig. 8. Alternate Method of Unloading Flywheel

Much faster rolling will be accomplished by the use of the largest rollers at hand up to 6 inches in diameter. When oak or other hard-wood rollers cannot be had, 4½- or 5-inch gas pipes are good substitutes. Plenty of rollers should be used to evenly distribute the weight, thus making easy rolling.

How to Build the Runway

The runway should be carefully built of timber of ample size to support the load, and be carefully lined and blocked. Getting ready is the longest part of the erector's job, and the novice should not make the error of starting the casting on its trip without due preparation, as the actual work of moving should occupy only a few moments under favorable conditions, while a poorly built runway may cause it to take many hours. Abrupt angles and bends in a runway should be avoided and the timbers should be lapped and not joined end to end.

Lowering the Wheel

On arriving at the engine, the shaft being already in place, with the journal caps bolted down, the wheel can be lowered and the runners removed by the same method reversed as used in loading. Guy lines should be kept taut and a number of 1x6-inch boards and other blocking, as long as the full width of the wheel face, should be provided so that the wheel can be blocked every inch of the way down. Fig. 6 shows the wheel over the crank shaft with the blocking and platforms ready upon which to work while lowering.

After the segment has been lowered to the shaft, clamps should be made of 6x8-inch hard wood and secured as shown in Fig. 7, the bolts belonging to the hub being used for the purpose. Three sets of blocks should be attached to hold the wheel level while the timbers and blocking are being removed. When everything is clear the segment can be rolled over into the pit, great care being exercised in having all the hitches carefully made and the fall lines securely snubbed preparatory to quickly and smoothly slacking away.

Tackle No. 3, in Fig. 7, sustains the weight as the wheel is drawn over by tackle No. 2. The weight increases as the wheel is turned and No. 1 then receives part of the strain until No. 2 engages, when No. 3 should be changed to the position shown in the dotted lines; this change should be made before the lines fall over edge *E*.

When to Use Jacks

It sometimes occurs that three sets of rope blocks suitable for the work cannot be obtained in the community where the engine is to be erected. In such a case, on a lighter wheel, heavy snubbing lines may be used, but if no kind of tackle is available the wheel must be turned over and lowered into the pit by means of jacks, which is a slow and laborious process.

The first segment having been lowered in the manner described, it may then be allowed to rest on blocks on the bottom of the wheelpit and the second segment may be run in and lowered to the shaft, the bolts inserted and the first half drawn up to place.

Another Method

Another method of loading the wheel is illustrated in Fig. 8. The skids are strapped to the sides of the wheel by means of bolts running through both in the manner shown. Care should be taken to use bolts large enough to permit tight clamping of the timbers against the wheel as a slip may be disastrous and in handling very large and heavy wheels blocking should be used under the spokes as an additional safeguard. A third bolt may be used in the center, passing through the shaft hole and clamping the timbers against distance blocking between them and the hub. If the center bolt is not used the straps should be nailed across from one skid to the other to prevent side buckling.

This method requires less jacking but unless very heavy timbers are used the broad surface, so desirable for smooth and easy running, is not presented to the rollers. After the skids are thus placed the wheel may be mounted upon the rollers in the same manner as before described.

Engineers' Wages in China

By Walter H. Adams*

I have been interested in reading the remarks of engineers concerning wages that have appeared from time to time in Power.

I think a few words regarding the scale of wages that I pay my men here may bring the "yellow peril" near to the men in the power plant.

I have a small plant of 30 kilowatts capacity for lighting the university. This same plant is used for pumping water for our water system of 25,000 gallons daily capacity and for supplying heat to our main building of 25 rooms.

The engineers and firemen are under my direct supervision. Under me is my chief engineer, who speaks, writes and reads English rather imperfectly. He receives $14.70 gold every month. His duties are to supervise all the other men and act as my interpreter. He can do electric wiring, pipe fitting and machinist work with very little supervision. His hours are 8 a.m. to 11:30 p.m.

Next comes the first assistant engineer, who receives the magnificent wage of $8.40 per month. His hours are the same and his duties are similar, except he does not have the responsibility and talks no English.

The second assistant engineer receives $3.80 per month. He is assistant, oiler and wiper, and is a youth whom the chief engineer breaks in as an engineer.

Then there is No. 1 fireman. His hours for firing are from 4:30 p.m. till 11:30

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p.m., but he is expected to be on duty from 8 a.m., and clean the apparatus in the boiler room and the boiler which is laid up at the time. He is responsible for the condition of the boiler room. He receives $5.10 per month. An assistant fireman helps No. 1 fireman and receives $4.20 per month. A "coolie" does the general cleaning and looks after the fires which we keep in our filters and pump houses to prevent freezing. He is on duty day and night as long as it is necessary to look after the soft-coal fires. He receives $3.40 per month.

In the winter an additional fireman is employed who looks after the boiler from 4 a.m. till 3 p.m., during which time it is used for heating. He receives $4.20 per month. This totals $43.80, or less than one man would receive in the United States.

These men do all the new wiring, keep all wires in repair on the circuit, supply 50 arc lamps with new carbons when necessary, do all the pipe work and they will do all the forging and machine work when I get my machine shop ready.

Of course, all this work, or the greater part of it, could be done by two men in the United States, but the amount paid as a total is less than that ordinarily paid to a good fireman.

The only additional thing provided by the university is unheated quarters. As these are unfurnished, I have often found my men sleeping on their beds in the coal bin or, in winter, on the top of the boilers. The beds consist of two saw horses with two planks placed on them.

I allow each man one day off every week but he has to return before evening so as to be ready for his work. Even this is the exception out here, where everyone works 365 days in the year.

When a man at home gets a "grouch" and thinks the boss is not treating him right, just let him think of the workmen out here and forget the "grouch."

British-Canadian Power Company

By G. C. Bateman*

One of several water-power developments which have cut Cobalt power costs from about $160 to $50 per horsepower-year. Electric power transmitted at 44,000 volts. Bleeder valves in air lines warmed by electric heaters.

*Mining engineer, Dome mines, South Porcupine, Ont.

The rich silver mines of the Cobalt district were discovered in 1904, and although at first it was believed that they were not extensive deposits, the camp has since developed into one of the most important of the world's producers of silver. During the year 1910 approximately 30,000,000 oz. were produced and the production for 1911 is estimated at about 35,000,000 ounces.

Steam Power About $160 per Horsepower-year

One of the most interesting features of this camp is the development of power on a large scale, for supplying air and electricity to the various mines. The camp embraces an area of approximately seven square miles, in which there are 30 shipping mines besides several nonshippers, and it lends itself readily to the large development of power. The distance of the Cobalt district from the coal-producing centers is great and as transportation is all-rail, the cost at the mines is necessarily high, averaging between $6 and $6.50 per ton; consequently coal-generated power is costly. A series of tests run at the different mines put the average cost for the camp at between $150 and $175 per horsepower-year.

Total Development, 15,000 Horsepower

The cost of power became a serious consideration in the cost of mining and several companies were formed to develop the large water powers near the district, for the purpose of supplying air and electricity to the mines. Among these was the British-Canadian Power Company, formerly known as the Mines Power, Ltd., which was promoted by E. A. Wallberg and F. J. Bell, of Montreal. This company secured a valuable water power on the Matabitchewan river, distant about 25 miles from Cobalt.

The main power dam is 860 ft. long and 50 ft. high at its deepest point. It raises the water 40 ft. above its former high level and gives a working head of 312 ft. It is estimated that a total of 15,000 horsepower can be developed. Several lakes above the dam have been utilized for storage purposes, so as to eliminate as far as possible the danger of a water shortage.

By means of an intake canal the water is diverted to two steel penstocks, each 5 ft. in diameter and 1075 ft. in length. Each penstock supplies water to two turbines. The power house is a solid concrete structure 57x105 ft. and is fitted with travelling cranes. The turbines are of the horizontal reaction type, consisting of a single runner in a spiral case with a speed of 600 r.p.m. and rated at 2750 b.h.p. each.

The electrical equipment consists of four 1875 kw. alternating-current generators, direct connected to the turbines. There are two exciters, each direct connected to a Doble impulse water wheel,

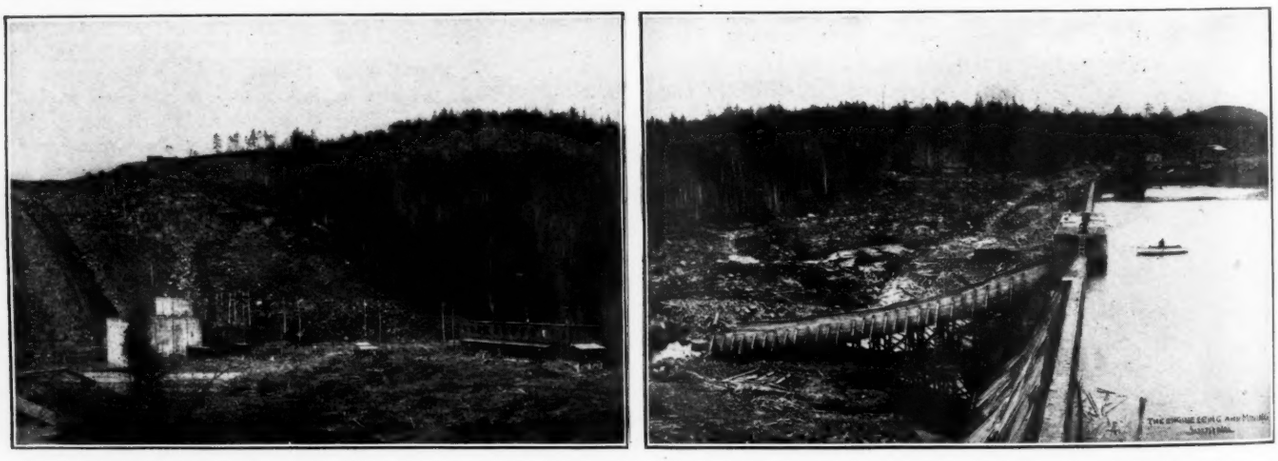


Fig. 1. Power House and Main Concrete Dam of British Canadian Power Company, on Matabitchewan River

rated at 180 h.p., 475 r.p.m. To insure perfect regulation, high-power governors are installed. The current is three-phase, 60-cycle, and is generated at a pressure of 2200 volts. By the use of step-up transformers the pressure is increased to 44,000 volts, at which potential it is transmitted to the power stations at Cobalt and South Lorrain.

Aluminum Transmission Wires Used

There are two separate three-phase transmission lines 35 ft. apart over a right-of-way 135 ft. wide. This right-of-way has been entirely cleared, and all tall trees on each side have been cut down. The conductors are stranded aluminum cables, and the poles are equipped with high-tension porcelain insulators that were subjected to the most severe tests before being used. The conductors on each pole line are of sufficient capacity to carry the whole power load, thus eliminating any danger of a shutdown due to a break in the line. The main transmission line is equipped with

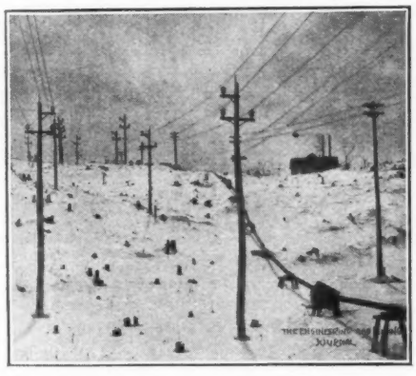


Fig. 2. Transmission Lines to Cobalt

a private telephone system and patrolmen are stationed at intervals.

At the Cobalt camp two brick and concrete substations have been erected, one at Cobalt lake with a capacity of 5500 h.p. and the other at Brady lake with a capacity of 3200 h.p. Each substation is equipped with all the necessary step-down transformers, lightning arresters, switching devices, etc. Electric current is delivered to the customer at 2200 volts, and by means of line transformers is reduced to 550 volts for motor service and 110 volts for lighting.

A substation was also built at South Lorrain to supply electric power to the mines of that section, which was destroyed by fire a short time ago, but has since been replaced by a concrete fireproof structure.

Both Meter and Flat Rates Used

Power is sold to the mines on a meter basis, with prices varying for the amount consumed and the class of service, or it is sold at the flat rate of $50 per horsepower-year. This rate is high in comparison with prices for power in other sections of the country, but is eminently fair when the immense cost of the undertaking is considered, and the fact that a much shorter life must be looked for than would be the case were the plant supplying power for industrial purposes.

At both the Brady Lake and Cobalt Lake substations, are identical compressor plants, each consisting of two 2-stage air compressors, each having a capacity of 5000 cu.ft. of free air per min., and each driven by a 1000-h.p. motor. When the compressors are running at full load they each take 1020 h.p. The compressors are equipped with the regular intercoolers, and each substation is equipped with an extra large water after-cooling system. From this the air passes through a separator, and from there through an air-cooling system. This latter system is not used in the summer, as the high temperature renders it useless, but it is in continuous use in the winter time.

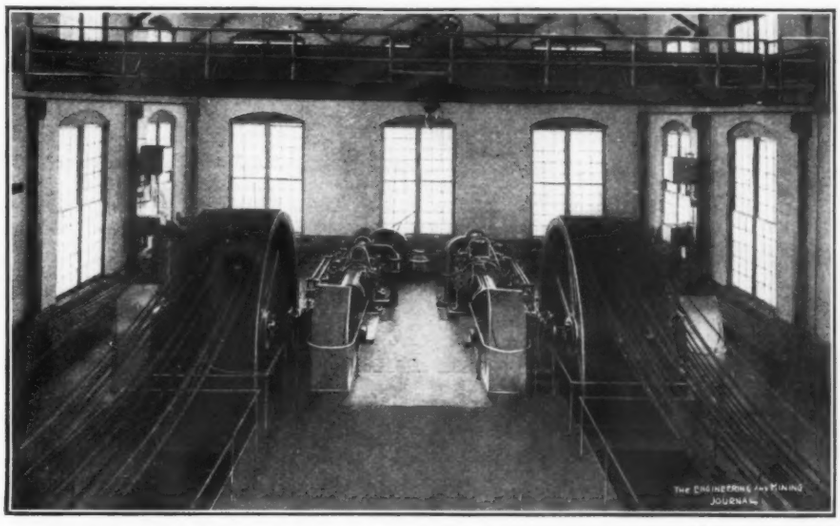


Fig. 3. Two 100-horsepower Compressors of British Canad'an Power Company

The air is delivered through steel pipes, with diameters varying from 3 to 10 inches, and the two substations are connected by a 10-in. main. All the pipes are lap-welded, and the larger sizes come in 40-ft. lengths. They are fitted with wrought-iron forged flanges welded on, and each pipe has a weld in the cross-section made by the oxyacetylene process, and they have been tested to a pressure of 300 lb. per sq.in. All fittings, valves, etc., are made of steel.

Pipes Zigzagged; No Expansion Joints

When this line was first under consideration it was decided not to install expansion joints, as they were not considered sufficiently reliable. To take care of the expansion and contraction, which are excessive, the lines were zigzagged and, although the plant has been in operation for two years, no trouble has as yet been experienced. In all there are about 15 miles of main lines and branches.

In the pipe lines there is at times a small accumulation of water. This is not of sufficient quantity to affect the mines, but as the water collects in the bottom of the hollows of the lines, it would freeze in the winter time and stop up the pipes. At the lowest point of each hollow, there is a ¾-in. cock that is left open just enough to allow the water to escape. In the winter time the pipe at the point where the cock is inserted is warmed by an electric heater, thus preventing the water from freezing, and keeping the cock open. The air is delivered to the mines at 100-lb. pressure and is sold at the rate of $2 per drill per shift.

Operations on this plant were started in the first part of June, 1909, and the first power was turned on March 17, 1910, which is an enviable record for a plant of this size. Air and electric service is now being supplied to 37 mines and concentrators. In addition to this the company supplies power for the electric railway between Cobalt and Haileybury, and furnishes electricity at wholesale rates to the Cobalt Light, Power and Water Company, which resells to the town of Cobalt.

There has recently been assigned to the Allis-Chalmers Company, Milwaukee, Wis., a patent for a turbine in which an exhaust pipe extends from an engine and is divided into two paths, one of which communicates with a condenser and the other path leads to the turbine. A governor controls valves which limit the flow through the two paths.

Superheated Steam, Interesting Tests

The paper deals with three tests made with a separately fired superheater at the University of Ohio: one to determine the percentage of the heat value of the fuel put by the superheater into the steam; one to determine the loss of heat and of pressure in the steam main with steam of different degrees of superheat and at different rates of flow; and one to compare the performance of a compound high-speed condensing engine when supplied with superheated steam with that when saturated steam was used.

Prof. Embrey M. Hitchcock, at the recent meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers, presented a paper upon the above subject. It was based upon experiments conducted as thesis work by Messrs. Cochrane, Foster and Bate, at the laboratories of mechanical engineering at the Ohio University, where Professor Hitchcock is engaged. The separately fired Foster superheater upon which the experiments were made has a capacity of 3500 pounds of steam per hour raised to 602 degrees Fahrenheit at a pressure of 125 pounds and a safe working pressure of 108 pounds. The effective heating surface is 84.92 square feet, exclusive of headers and manifolds. With a grate of 6.33 square feet the ratio of heating to grate surface is 13.4. The rated capacity involves the transmission of 5358 B.t.u. per hour per square foot of internal heating surface, which is 58 per cent. greater than that of the average boiler-heating surface based upon the evaporation of 3.5 pounds of water per hour per horsepower from and at 212 degrees. The paper deals with three tests, one on the pipe line to determine the drop in pressure and temperature at different rates of flow, one on the superheater itself, and the third on a McEwen tandem-compound engine running condensing and using, first, saturated steam and then steam from the superheater.

Pipe-line Tests

In conducting the pipe-line trials the quantity of steam flowing through the superheater line was made constant for a sufficient length of time before the trials to secure continuity of conditions. In order to obtain the average external temperature, and thus to reduce all losses to the basis of B.t.u. per square foot per degree of temperature difference, three thermometers were suspended along and about 3 feet directly under the header. The total distance from the superheater to the end of the header, or gage to gage, is 121 feet, and the line contains two tees and three elbows. The area of the heating surface is based upon the outside dimensions of the pipe line. The surface of the header between the points at which the temperatures were taken is 61.3 square feet.

Immediately following the trials of the uncovered line it was covered double with 1 inch of fire felt and 1 inch of 85 per cent. magnesia. The results obtained on the covered and uncovered pipes are given in Table 1.

The results obtained for the uncovered-pipe test check the general value usually taken for heat loss per B.t.u. per hour per degree difference in temperature for uncovered pipe—that is, 3 B.t.u.—but at the same time there is shown a drop in this loss with a drop in velocity of the steam through the line. The results obtained with the line covered run somewhat above the values usually given for cases of covered line, and, with the exception of the first trial of this set, the results indicate a practically constant loss under variable conditions. It will be observed that the temperatures carried in the line were such as to give a small amount of superheat at the end of the header.

TABLE 1

	Pressure, Pounds		Temperature, Fahrenheit				Drop in pressure from superheater to end of header.	Drop in temperature from superheater to end of header.	Drop in temperature along header.	Total pounds of steam through header per hour.	Velocity of steam through header, feet per minute.	B.t.u. loss per hour from header.	B.t.u. loss per hour per square foot.	B.t.u. loss per hour per sq.ft. per degree difference in temperature.
	Leaving superheater	End of header	Leaving superheater	Header entrance	End of header	Room								
Uncovered	80.0	76.3	388.0	361.4	335.0	86.9	3.7	53.0	26.4	3,559	6,550	50,800	795	3.08
	79.5	77.0	422.0	375.5	336.0	83.3	2.5	86.0	39.5	2,431	4,505	50,900	796	2.96
	78.5	77.0	513.0	399.1	334.5	84.1	1.5	78.5	64.6	1,268	2,387	43,400	687	2.43
	97.6	94.2	402.5	371.7	346.0	86.2	3.4	56.5	25.7	3,656	5,635	52,600	833	3.06
	95.6	95.0	445.5	389.5	345.5	77.4	0.6	100.0	44.0	2,243	3,500	54,250	858	2.96
	96.5	95.4	550.0	404.1	343.0	81.3	1.1	107.0	61.1	1,130	1,780	38,000	602	2.06
	124.9	121.8	424.0	391.4	362.1	83.2	3.1	61.9	29.3	3,672	4,630	62,400	988	3.36
	124.0	123.0	504.0	423.8	369.5	83.4	1.0	134.5	54.3	2,000	2,560	60,900	964	3.07
Covered	79.1	77.6	343.5	342.8	334.6	88.9	1.5	8.9	8.2	2,496	4,500	11,210	178	0.713
	77.5	77.3	354.3	346.7	335.0	90.5	0.2	19.3	11.7	1,237	2,230	7,920	126	0.503
	97.3	94.4	350.2	348.2	344.0	87.7	2.9	6.2	4.2	3,408	5,140	7,990	127	0.493
	96.3	94.9	350.1	348.0	342.5	89.4	1.4	7.6	5.5	2,540	3,826	7,800	123	0.483

Superheater Trial

In preparing for a test of the superheater a Barrus calorimeter and pressure gage were connected to the supply line close to the superheater, in addition to a pressure gage and a Hohmann & Maurer standard thermometer at the outlet. For obtaining the drafts and the temperature of the escaping gases Ellison inclined draft gages and a Hohmann & Maurer mercurial pyrometer were used. An Orsat apparatus with a continuous gas sampler and collector was used for obtaining the composition of the escaping gases. In order to have the superheater in a well heated condition, it was fired up at 1 a.m. of the day of the trial and was run steadily until the test began at 7:45 a.m.

The following are the general results obtained:

General Dimensions of Superheater

Number of elements	21
Diameter tubes, internal, inches	1.8
Diameter tubes, external, inches	2.0
Length of element	4 ft. 3.5 in.
Area heating surface inside, square feet	84.92
Kind of furnace	hand fired, shaking grate
Dimension of grates, 3 feet 2 inches by 2 feet 6 inches, square feet	6.33
Ratio of grate area to inside heating surface	1 to 13.4
Area opening into flue, square feet	2
Floor space, 9 feet 8 inches by 5 feet 4 inches, square feet	51.2

Conditions

Date of trial	June 6, 1911
State of weather	Clear
Duration of trial, hours	10
Kind of fuel	Pocahontas run-of-mine

Average Pressures

Steam pressure by gage, entering superheater, pounds	107.7
Atmospheric pressure by barometer, inches	29.25
Absolute steam pressure, pounds	122.1
Steam pressure by gage, leaving superheater, pounds	100.2
Steam pressure by gage, end of header, pounds	95.0
Force of draft over fire, inch	0.036
Force of draft leaving superheater, inch	0.091

Average Temperatures

Fire room, degrees Fahrenheit	90.2
Products of combustion leaving superheater, degrees Fahrenheit	580.3
Steam leaving superheater, degrees Fahrenheit	564.8

Fuel

Kind of firing	spreading
Thickness of fire, inches	4
Weight of coal fired during trial, pounds	828
Weight of refuse, pounds	43
Per cent. refuse to coal	5.18

Proximate analysis in per cent.	
Moisture	0.96
Volatile matter	19.06
Fixed carbon	75.82
Ash	4.16
Ultimate analysis in per cent.	
Carbon	87.35
Hydrogen	4.26
Oxygen	2.65
Nitrogen	0.86
Sulphur	0.72
Ash	4.16
Analysis refuse in per cent.	
Combustible	22.0
Ash	78.0
Calorific value of fuel by Mahler calorimeter, B.t.u.	14,986

QUALITY OF STEAM

Moisture in steam entering superheater, per cent	1.00

STEAM

Weight of wet steam entering superheater, pounds	45,892
Weight of dry steam entering superheater, pounds	45,433
Weight of water entering superheater, pounds	459

STEAM PER HOUR

Weight of water evaporated and superheated, pounds	45.9
Weight of dry steam superheated, pounds	4,543.3

ECONOMIC RESULTS

Water evaporated and superheated per pound coal, pound	0 544
Steam superheated per pound coal, pounds	54.866
B.t.u. taken up by water per pound coal	549.3
B.t.u. taken up by steam per pound coal	6,337.0
Total B.t.u. per pound of coal	6,886.3
Efficiency of superheater, per cent.	45.95

FLUE-GAS ANALYSIS

Carbon dioxide by volume	7.11
Oxygen	12.70
Carbon monoxide	0.00
Nitrogen	80.19

HEAT BALANCE PER POUND OF COAL

	B.t.u.	Per Cent.
Loss due to latent heat	392	2.62
Loss due to products of combustion	1,470	9.82
Loss due to air excess	2,010	13.42
Loss due to unburned coal	164	1.09
Loss due to radiation, etc.	4,064	27.10
Heat used in superheating	6,886	45.95
Total heat supplied	14,986	100.00

At first glance, the efficiency obtained, 45.95 per cent., would seem low, but when the size of the superheater and the area of the fire door in relation to the grate area are considered, the results obtained are to be expected. The heat taken up per hour per square foot of internal heating surface was 6714 B.t.u., or 25 per cent. in excess of the superheater rating. The maximum velocity of the steam through the elements was 7000 feet per minute with a drop through the superheater of 7.5 pounds and a drop from the superheater to the end of the header of 5.2 pounds, with an average velocity in the line of 8500 feet per minute.

ENGINE TRIALS

The McEwen engine is a horizontal tandem-compound with an inertia governor controlling the admission to the high-pressure cylinder only. The load was supplied by a brake. During the superheat trials the temperature of the steam was taken in the high-pressure steam chest.

ENGINE DIMENSIONS

Diameter high-pressure cylinder, inches	8.2
Diameter high-pressure rod, inches	1.75
Clearance high-pressure cylinder head, per cent	12.71
Clearance high-pressure cylinder, crank end, per cent	13.64
Diameter low-pressure cylinder, inches	13.24
Diameter low-pressure rod, inches	2.25
Clearance low-pressure cylinder head end, per cent	11.86
Clearance low-pressure cylinder, crank end, per cent	11.23
Stroke, inches	12.0

RESULTS

Number of run	1	2	4	5
R.p.m. continuous counter	284	289	285	286
Pressure at throttle by gage, pounds	110	109.2	100.4	100.5
Pressure in receiver, pounds	1.3	6.7	3.8	6.1
Vacuum in exhaust line at engine, inches	25.3	25.3	25	24.9
Moisture in steam at throttle, per cent	1.26	1.92		
Temperature of steam in steam chest, degrees Fahrenheit			419.4	427.2
Degrees superheat in steam chest, degrees Fahrenheit			81.3	89.0
Weight of dry steam per hour from condenser, pounds	843	1113	858	1036.5
I.h.p., high-pressure cylinder	13.89	23.78	23.44	31.35
I.h.p., low-pressure cylinder	20.84	28.70	23.07	28.66
I.h.p., total	34.73	52.48	46.51	60.01
Dry steam per i.h.p.-hour, pounds	24.28	21.23	18.44	17.27
Thermal efficiency, per cent	9.54	10.91	12.15	12.92

The results obtained per pound of dry steam per indicated horsepower per hour on the two trials with saturated steam—when referred to a water-rate curve for this same engine obtained a short time previous to these trials while running under practically the same conditions through a range of six loads varying from 36.5 to 77.5 indicated horsepower—exceed those results by about 0.1 pound of steam per indicated horsepower-hour, or a difference of 0.5 per cent. Therefore, referring to this water-rate curve for the loads carried on the superheat trials, the rates for saturated and superheated steam for the 46.51 and 60.01 indicated horsepower loads are 22.25 and 20.1 pounds as against 18.44 and 17.27 pounds, or an excess of steam for the three-quarters load of saturated over superheated of 20.6 per cent., and for the full load 16.9 per cent.

FIG. 1. BOILER FUEL-TESTING LABORATORY OF OHIO STATE UNIVERSITY

AN ASSUMED CASE

Although the use of superheated steam in this unit as well as others shows a marked degree of reduction in the weight of the steam used, this does not indicate the fuel or net saving, as all losses and additional fuel costs to produce the superheat are not considered.

Taking the case of an assumed plant of such a capacity as to require a superheater of the size of the one under consideration, and taking this plant into account with and without the superheater, the difference in fuel consumption could be computed as herewith shown.

This assumed plant is to have a normal capacity equal to that of the superheater when giving, say, 100 degrees Fahrenheit superheat at 120 pounds gage pressure. From the above superheater test, considering the same efficiency as obtained, this capacity would be 8890 pounds of steam per hour and on a basis of 17.27 pounds of steam per indicated horsepower-hour for the engine water rate, would give an engine or engines of 510 indicated horsepower. Consider the line from the superheater to the engine to be extra-heavy 3.5-inch pipe and 100 feet in length with double covering. The velocity of the steam through this line would be 8300 feet per minute, with a loss in heat due to radiation, of 2 B.t.u. per pound of steam, or a drop in superheat of 3.6 degrees Fahrenheit. The drop in the pressure through the superheater would probably be 15 pounds with a drop through the line of 5 pounds, or

a total drop of 20 pounds, giving a pressure at the engine of 100 pounds. Taking the efficiency of the superheater practically the same as that obtained on the test, or 45 per cent., and figuring on a good grade of Hocking coal having 12,000 B.t.u. per pound, the coal required per hour for superheat would be 105.5 pounds. Considering the boiler generating the steam and using the same coal, and having an efficiency of 65 per cent., the coal required per hour by the boiler with a gage pressure of 120 pounds and a feed-water temperature of 200 degrees Fahrenheit would be 1156 pounds, or a total for the boiler and the superheater of 1261.5 pounds.

Eliminating the superheater and considering the engine using saturated steam only, the total steam required by the engine would then be 10,251 pounds per hour. Taking the usual saturated steam velocity of 6000 feet per minute, the estimated steam-line diameter would be 4.5 inches and in all probabilities in practice, a 5-inch line would be installed. This size line would give a radiation loss of 18,750 B.t.u. per hour, which would be equivalent to the condensation in the line of 21 pounds of steam per hour, thus making the total dry steam required from the boiler 10,272 pounds per hour. Consider as before the boiler efficiency as 65 per cent. at a pressure of 105 pounds and a feed-water temperature of 200 degrees Fahrenheit; the coal required per hour would be 1343 pounds, an increase of 81.5 pounds per hour, or 6.45 per cent., which would stand for a saving for a working year of 3000 hours of 122.2 tons.

In considering the financial aspect of the problem the elements entering in are the number of hours the plant is in operation, the cost of fuel, additional operating costs, if any, depreciation, etc. These elements would vary with each individual plant, depending upon its location, character of design and construction and its operation, so, therefore, the advisability of using superheated steam in any plant is a problem for the owner, or the designing or operating engineer.

Discussion

Asked about the investment and maintenance, Professor Hitchcock said that the cost of the superheater was $1000. They set it up themselves. The attendance would not amount to anything, as but 825 pounds of coal were fired in 10 hours. Used with natural gas, it would be ideal, permitting an easy regulation of the amount of superheat. The superheater, partly on account of the mass of cast iron surrounding the heating pipes, is not sensitive to changes of conditions, and it would take some time for the temperature of the steam to change when the drafts and the rate of steam flow were altered.

President Rabbe had had some experience with superheaters in Stirling boilers which gave trouble through variable superheat. Conditions were improved, through a better control of the feed water. He said that one of the engineers of a large electric company had told him that they did not want more than 100 degrees of superheat.

Professor Hitchcock said that the engineer of a large plant using 170 pounds and a little over 100 degrees of superheat had told him that if he were going to build a new plant he would cut the pressure down to 150 pounds and use 200 degrees of superheat.

Mr. Beebe, of the Fisher Regulator Company, said that the Chicago Northwestern Railway cut its steam pressure from 210 to 170 and put in superheaters with a saving of 4 tons of coal per trip. Some of the engineers burned out the superheaters by shutting off the steam and letting the train drift into the stations.

Professor Hitchcock said that over 200 degrees of superheat were being used on the Fort Wayne division.

A member said that the claim was made that notwithstanding its higher temperature, there was less loss by radiation with superheated than with saturated steam. He referred to recent researches on superheated steam by Dr. Armand Duchesne at Liège, where temperatures were measured both with a silver-platinum thermocouple and with mercury thermometers in the regular way. While the steam was saturated the temperatures indicated by the two methods were alike, but as soon as superheating set in there appeared a very material difference. The mercury thermometer read low, evidently because it was indicating the temperature of the somewhat cooled film of steam gas about its well and not the temperature of the whole mass. This difficulty of communicating the heat from the gaseous superheated steam to the metal of the pipe is the probable cause of the lesser radiation if such exists; but Professor Hitchcock's tests show fully as much loss per degree difference of temperature as the recorded tests with saturated steam, and since the temperature difference is greater the radiation loss must be increased instead of diminished.

Pounds of steam are not a fair basis of comparison as between saturated- and superheated-steam performances, because the superheated steam contains more heat per pound. He had computed the heat consumption in B.t.u. and the Rankine efficiencies—that is, the ratio of the heat units required by an engine of 100 per cent. efficiency working in a Rankine cycle between the limits given and the actual number of heat units required. These are given in the accompanying table and show the improvement in the Rankine efficiency to be between 6 and 7 per cent.

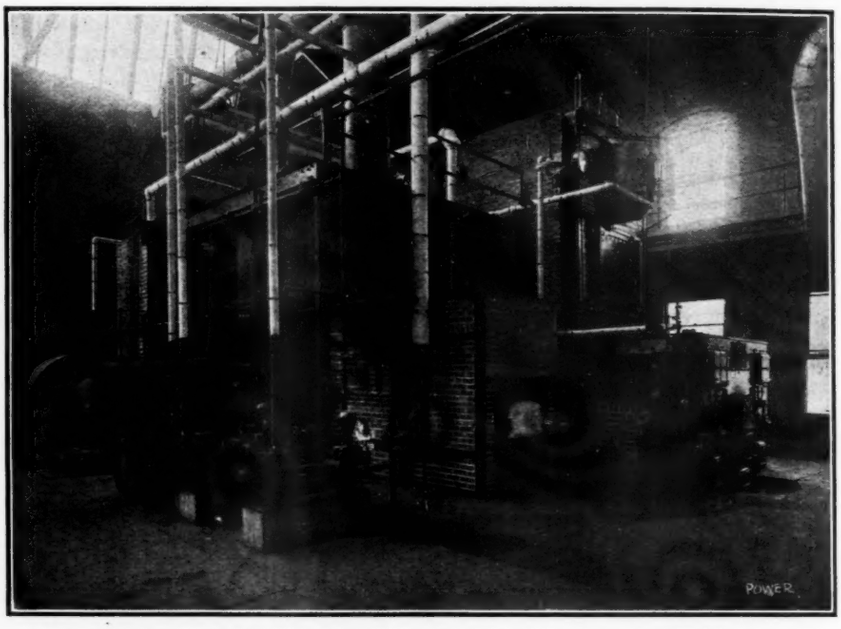


Fig. 2. Babcock & Wilcox Experimental Boiler and Foster Superheater

TABLE 2

Load, I.h.p.	Steam, Pounds per I.H.P.-hour		B.t.u. per I.H.P.-minute		Rankine Efficiency, Per Cent.		Improvement in Rankine Efficiency by Superheating, Per Cent.
	Saturated	Superhea'd	Saturated	Superheated	Saturated	Superhea'd	
34.73	24.28	.....	439.57	.....	37.19		
46.51	22.25	18.44	406.40	350.19	42.9	49.59	6.69
52.48	21.23	.....	382.17	.....	44.9		
60.01	20.10	17.27	367.13	328.22	47.5	53.5	6.00

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Operation of Interpole Motors

By Gordon Fox

Interpole motors are now being extensively used for variable-speed service, for high-speed operation and to handle widely fluctuating loads, nearly all of the commutation troubles previously developed by these classes of service having been eliminated by means of the interpole construction. However, the auxiliary poles add some complication to the ordinary shunt-wound machine and frequently troubles arise from misunderstanding of their exact functions. The purpose of the intermediate poles is to neutralize the effects of armature reaction and self-induction and to maintain a fixed electrical neutral point, allowing the brushes to be set permanently at one place and to effect practically sparkless commutation at all loads. In an ordinary shunt- or compound-wound motor, when the load increases, the neutral point shifts backward with respect to the direction of rotation, by reason of the magnetic reaction of the armature winding. A study of Figs. 1, 2 and 3 will help to make this clear. Fig. 1 shows approximately how the magnetic flux passes from a field-magnet "north" pole to the armature core when no current is flowing in the armature winding. Fig. 2 indicates the direction of the magnetic flux that would be produced by current in the armature winding alone. By comparing this with Fig. 1 it will be evident that the armature magnetism opposes the field magnetism in the right-hand half of the magnet pole and airgap and agrees with it in the other half; the arrows *A* give the direction of magnetic force due to the armature current and the dotted arrows show the direction of magnetic force due to the field winding when it is excited. The result is distortion of the field flux somewhat as indicated in Fig. 3. The armature magnetic force is too weak to neutralize entirely the magnetic force in the right-hand half of the pole, but it neutralizes some of it and increases the flux in the left-hand part, near the poleface, producing the same result as though the field flux had been pushed over physically.

The actual neutral point on the armature is exactly midway between the central part of the flux under one pole and the corresponding point under the neighboring pole, when the flux is evenly distributed, as in Fig. 1. When the flux is crowded more in one place than another, as in Fig. 3, the central point is near the densest part of the flux, as at *C*. Comparing Figs. 1 and 3 in this respect, it will be found that in the latter the armature reaction has shifted the central point of the flux back about 1½ armature teeth; the neutral point, therefore, will also have been shifted backward to the same extent, and brushes which were on the neutral points of the commutator when the flux was evenly distributed, as in Fig. 1, will be about 1½ bars ahead of the actual neutral points if the field becomes distorted by armature reaction as in Fig. 3. On an ordinary shunt-wound machine it is common practice to set the brushes in an intermediate position between the no-load and full-load neutral points, usually at the point where commutation is best with that load which is carried most of the time.

In a properly adjusted interpole motor the neutral point remains fixed, regardless of the load. With the brushes properly set the motor should be reversible and show the same speed characteristics in both directions; this is a good criterion as to the correctness of the brush position. The polarity of the interpole is the same as the polarity of the preceding main pole. If the interpole is too strong or if the brushes are given a backward lead, the main field flux will be partially neutralized and the result is much the same as though the field had been weakened; the resultant commutating points will be shifted away from the brushes and the motor will probably race, because of the reduced counter electromotive force at the brushes. This will be caused by excessive interpole magnetism only with considerable load, because the interpoles are magnetized by the armature current and their strength depends on the load. Fig. 4 shows the interpole flux alone and comparison with Fig. 2 will show that it is opposed to the magnetic forces of the armature winding. Fig. 5 shows the main and interpole fluxes combined.

From the foregoing it will be clear that the interpoles can affect the speed regulation of a motor. When an interpole motor drops off in speed from no load to full load, it is probable that the interpoles are not sufficiently strong, whereas

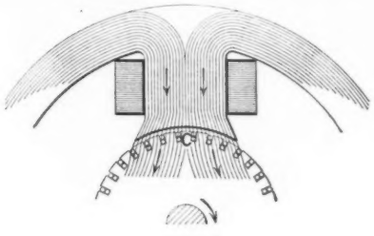


Fig. 1.

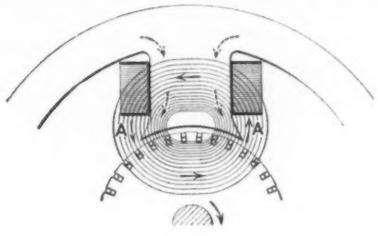


Fig. 2.

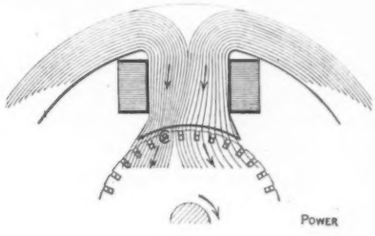


Fig. 3.

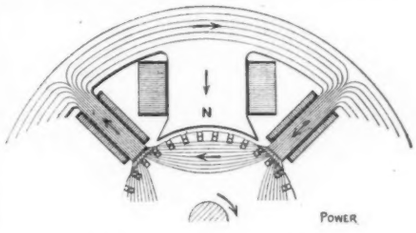


Fig. 4. Interpole Flux Alone

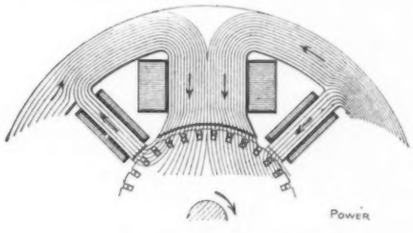


Fig. 5. Combined Fluxes

if the speed increases with increasing load the interpoles are too strong. When properly adjusted an interpole motor will run at nearly the same speed at all loads. For this reason the term "regulating pole" is sometimes used.

In most motors the interpole winding is made with a few excess ampere-turns and correct adjustment is obtained by shunting the winding with german-silver wire or ribbon.

FIG. 6. COMMUTATOR POTENTIAL "EXPLORER"

An excellent method of testing the brush setting and interpole strength is by exploring for the neutral. Two pieces of No. 6 insulated wire are soldered to the ends of a piece of lamp cord, the free ends of the wires bared for about an inch back and the wires taped together side by side, as illustrated in Fig. 6; the ends of the No. 6 wires should be bent to such a distance apart that they will just span two commutator segments. The free ends of the lamp cord are connected to a low-reading voltmeter. The points are moved around the surface of the commutator, as indicated in Fig. 1, until a position is reached where the voltmeter needle indicates exactly zero, denoting no voltage between bars. The neutral point should be thus determined at no load and the brushes set exactly over this point of the commutator. A load should then be put on the motor and the neutral point again determined. If this neutral point is beyond the no-load neutral in the direction of rotation, the interpole winding is too strong; if behind the no-load neutral, the winding is too weak. With the interpole strength correctly adjusted the neutral point will be in the same place at no load and full load.

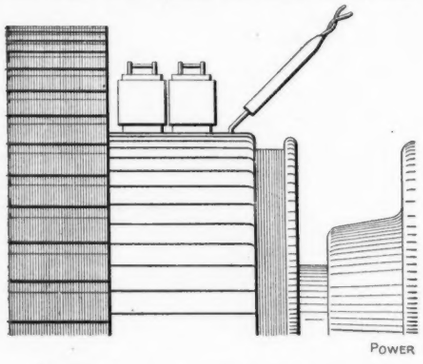


FIG. 7. EXPLORING THE COMMUTATOR

When a variable-speed interpole motor is running with a weakened field it will often be found that the commutating zone is quite narrow; that is, the voltage between bars increases rapidly on each side of the neutral point and a slight brush shift will cause sparking or racing. In such cases it is particularly desirable to have the brushes accurately spaced. The easiest method of locating the brushes is by means of a spacing strip. A strip of heavy wrapping paper about an inch wide is wrapped completely around the commutator under the brushes, allowing the ends to overlap, as represented in Fig. 8, and a cut is made across the overlapped ends along a mica segment, so that the length of the paper will be the exact circumference of the commutator. The paper is then removed and its length divided into as many equal sections as there are brush studs, and the divisions marked with a sharp pencil. It is then again laid around the commutator under the brushes, with one end even with the edge of one brush (see Fig. 9); the remaining studs are set so that the edges of the brushes will "toe" the marks. The fiber washers which insulate the studs often shrink somewhat after heating and allow the brush studs to become displaced.

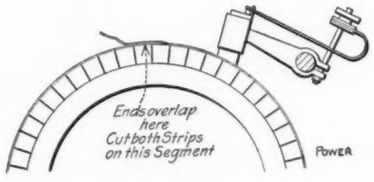


FIG. 8.

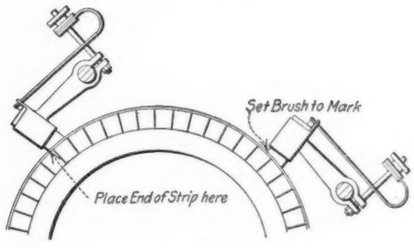


FIG. 9.

When it is desired to reverse the direction of rotation of an interpole motor, either the shunt field winding or the armature circuit, *including the interpole winding,* may be reversed. Never reverse the armature without also reversing the interpole winding. When either the armature or the interpole winding alone is reversed, the brushes spark and burn under a load and the motor usually gives out a decided hum; also, the speed drops off very decidedly with an increase of load.

Fig. 11 shows how the shunt field connections of Fig. 10 should be reversed; the leads f_1 and f_2 are merely exchanged where they connect with the external leads F and N. Fig. 12 shows the armature connections of Fig. 10 reversed incorrectly, the armature itself being reversed and the interpole winding left unchanged. The correct way to reverse the armature circuit of Fig. 10 is to transfer the lead N, together with the shunt lead f_2, from the brush cable B to the interpole terminal M and transfer the lead P from the interpole terminal to the brush cable B. This will reverse the current through both the armature and the interpole winding and keep the direction through the shunt field winding unchanged.

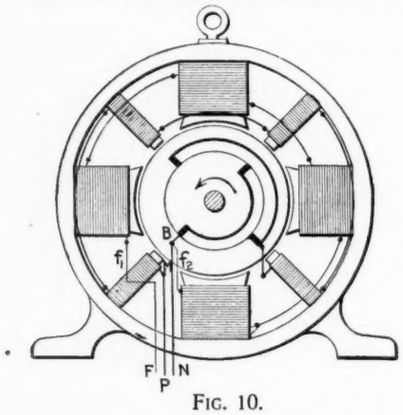


FIG. 10.

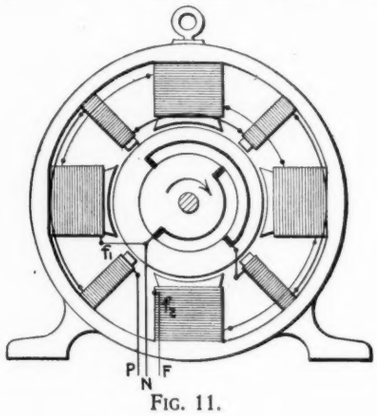


FIG. 11.

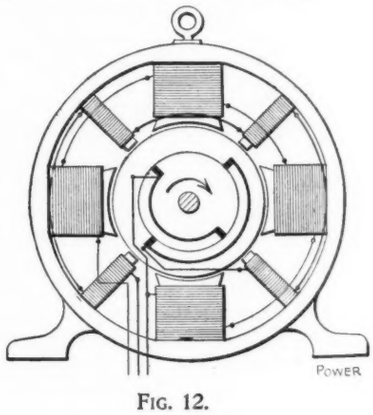


FIG. 12.

LETTERS

Mr. Hawkins' Compressor Motor

In the issue of October 31, J. C. Hawkins asks for advice concerning a sparking commutator. With the information given, it is difficult to decide just what is the cause of his trouble; but it frequently happens that owing to wear of the bearings the center of the armature is dropped somewhat so that the field in which the armature works is not uniform. This results in the brushes not working in the proper commutating location, and it may be that this is the cause of Mr. Hawkins' trouble. It also happens that the field strength of the various poles is not always uniform, and, therefore, the brushes are not actually located at the proper points of commutation. It might be worth while for Mr. Hawkins to explore the potential about his commutator, and see that his brushes are located at the proper commutating point. With brushes fixed on a yoke, as they usually are, it might readily be that some of the brushes are properly located and the others not; this is frequently a cause of very vicious sparking, resulting in badly pitted or heated commutators, which in the course of a very short time results in the machine running very hot and the commutator getting in a bad condition. This trouble can usually be located by the commutator being marked pretty badly on certain definite bars, and also being discolored on the same bars to a greater extent than on any of the others.

HENRY D. JACKSON.

Boston, Mass.

There may be several causes of Mr. Hawkins' brush sparking. If the compressor is the cause, it should be noticeable by watching the spark. If the brushes spark perceptibly more at each compressing stroke than at other times, this would indicate that the flywheel on the compressor is not heavy enough. This may also be detected by watching an ammeter in the motor circuit; if the needle swings badly it indicates the same trouble, the average of the swing showing whether a momentary overload is put on the motor. I have seen the same effect produced by reciprocating printing presses, each reversal of the bed causing a violent swinging of the ammeter needle.

Another possible cause is too high resistance in the brushes. If after cleaning the commutator and brushes the motor works all right for a few hours and then begins to spark, with a general blackening of the commutator bars, I should say the brushes were of too high resistance; a change to brushes of less resistance should cure this trouble.

Sometimes the brushes cover too many commutator segments and therefore spark badly. When a commutator is new the brushes may cover the right number of bars but as it is turned down the bars narrow up, being wedge-shaped, and the brushes overlap another segment and cause sparking.

Brushes that have been in use for a long time and have been heated and oil soaked sometimes give trouble, which new, clean brushes will cure.

In dressing a commutator I use No. 1½ sandpaper first, then No. 00 to finish, using oil on both kinds; the oil collects the copper dust and prevents its getting all over the generator or motor, and it also gives a better finish. For the final gloss I use a liquid polish on a piece of waste, after sandpapering. This gives a good smooth surface for the brushes.

In offering the foregoing suggestions I have assumed that the motor has no grounds or other internal troubles.

HOMER J. WHITE.

Keene, N. H.

Changing a 220 Volt Armature to 110 Volts

We recently wished to put in an extra shop motor but the only motor at hand was a bipolar, 220-volt machine, and our service voltage was 110. I therefore decided to change the motor to 110 volts. The field winding was easy; the two field-

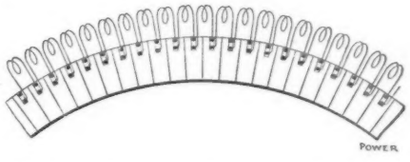


FIG. 1. ORIGINAL COMMUTATOR CONNECTIONS

magnet coils were simply connected in parallel instead of in series.

The armature was a more tedious job. In order to avoid rewinding the armature, I had to reconnect the winding at the commutator so as to put one-fourth of

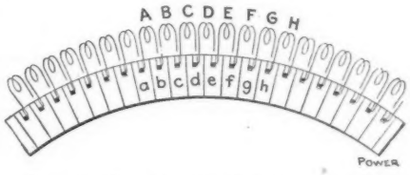


FIG. 2. TOP LEADS ALL LIFTED OUT

the coils in series in each of four parallel groups. First, I took the top wires out of three commutator lugs and tested to see where the other end of the middle coil was connected; the test showed that the bottom wire in one lug and the top wire in the next lug *to the right* were the terminals of one coil, as indicated in Fig. 1. Then I unsoldered the top wires from all of the lugs, leaving the bottom wires undisturbed, as in Fig. 2. The top wire from the lug *a* was moved over to lug *b*, the top wire from *b* transferred to *c*, and so on all around the commutator, as indicated in Fig. 3. This put the coils *A*, *C*, *E*, etc., in one group around the armature and the coils *B*, *D*, *F*, etc., in another

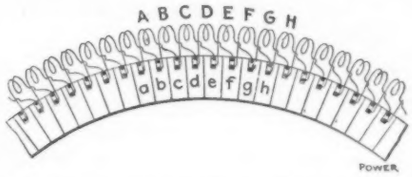


FIG. 3. TOP LEADS MOVED OVER ONE BAR

evenly distributed group, the two groups being separate from each other and connected symmetrically to alternate commutator bars, as shown in Fig. 4. Then I got brushes with faces wide enough to cover three commutator bars, and set these as usual; the wide faces connected the two sets of coils in parallel, as shown. In order, however, to insure stable parallel connection between the two groups, I

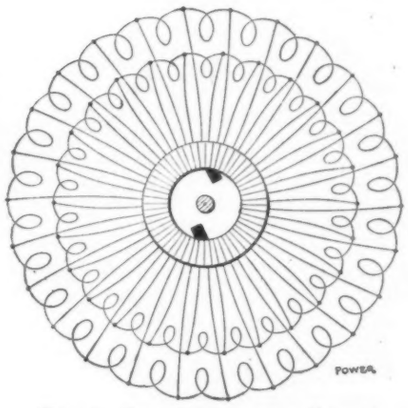


FIG. 4. DIAGRAM OF THE RESULT

put "jumpers" from bar to bar of the two sets of commutator bars; one from bar *a* to bar *b*, one from *c* to *d*, one from *e* to *f*, and so on all around.

This arrangement gave four paths instead of two through the armature winding, each one containing half as many coils as were in series before the change; as the number of coils in series was one-half and the number in parallel twice as great as originally, the armature voltage was reduced one-half and the current-carrying capacity doubled.

The change could not have been made satisfactorily if the commutator had had an odd number of bars, because the two groups of coils would not have been equal.

W. RUSSELL COOPER.

Indianapolis, Ind.

The use of a log sheet forms a practical routine reminder of the engineer's daily duties, and it keeps him on the alert to details of operation which might otherwise fail of constant inspection.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Test of an Oil Engine*

By Forrest M. Towl

A test of a De La Vergne Type FH oil engine was made at the pumping station of the Standard Oil Company, Fawn Grove, Penn., on April 20 and 21, 1911. The engine was an 85-horsepower machine with one cylinder 17x27½ inches and running at about 180 revolutions per minute. This type of engine operates on the well known four-stroke cycle, but the fuel is injected into the cylinder at the completion of the compression stroke instead of being drawn in gradually, as in the gas engine.†

Before shipment the engine was tested and developed a brake horsepower with 0.474 pound of Solar fuel oil per hour when running at 65.11 brake horsepower, and 0.462 pound when running at 85.74 brake horsepower.

In order to obtain as accurate data as possible, not only of the engine but of the combined pumping plant, it was decided to make a second brake test at Fawn Grove with the engine doing practically the same work as when pumping, and to ascertain as accurately as possible the ratio between the brake horsepower and the pump horsepower.

In preparation for the test, a Government-sealed platform scale, weighing to single ounces, was procured for weighing the oil. The water for cooling purposes was taken by gravity from a tank and allowed to waste, the amount used being computed from measurements taken. The inlet temperature was taken at the tank, and the temperature of the water after passing the jackets by placing a thermometer in the line near the engine.

The amount pumped was ascertained by gaging the tank at Fawn Grove, and checked by gaging the tank into which the oil was pumped. The pressure was recorded by a Bristol recording gage and also read on a special Ashcroft gage, the latter, on the completion of the test, being taken to New York and compared with the standard gage of the company, which is graduated from a mercury column, situated in the Standard Oil building, high enough to give direct readings up to 875 pounds per square inch. The temperatures were taken with standardized thermometers, and the cards with a Crosby indicator, which was returned to the makers at the close of the test and found to be correct.

The exhaust gases were tested on the ground by using an Orsat apparatus. Samples of the oil were tested for calorific power. The average as obtained by one observer was 19,059 and this figure was used in working up the tests. Two tests were made by another observer and recorded 18,920 and 19,300 B.t.u. Prof. H. C. Sherman's formula, B.t.u. = 18,650 + 40 (Baumé degrees — 10)* makes this 19,570. This formula is roughly applicable to all the American crude oils.

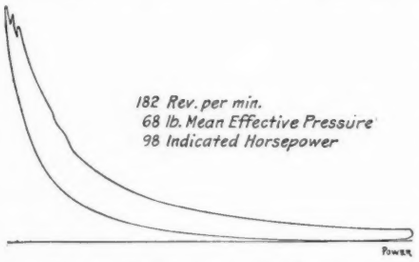


Fig. 1. Representative Diagram

No analysis of the oil was made, but for the purposes of chemical calculations it was assumed to be as follows, by weight:

Carbon	0.86
Hydrogen	0.12
Other material	0.02

The accuracy of the method used in analyzing the gases is not such as to warrant going to the trouble of making an analysis of the oil. By comparison with available analyses the above is believed to be substantially correct.

Three tests were made: the first, *A*, a full-load prony-brake test; the second, *B*, a pumping test using the engine under the actual operating conditions; and the third, *C*, without disturbing any of the engine adjustments but simply substituting the brake load for the pump load, so that the oil consumption and speed were, as nearly as possible, the same. By comparing *B* and *C* it was thought that the friction of the pump could be more accurately ascertained than in any other way. There was no auxiliary machinery used, the cooling water being delivered by gravity.

The duration of each test was 3 hours, and the hours checked so closely that it was considered unnecessary to continue the runs for a longer period.

The number of revolutions per hour was obtained by using an Ashcroft counter. During test *B* the counter was on the pump and the revolutions were computed in the ratio of the gearing; during tests *A* and *C* the counter was connected direct to the engine. The resistance of the pump load, test *B*, was so constant and the regulation of the engine so good that the number of counts recorded for each hour was the same. The fuel consumed for the first hour was 31 pounds 2 ounces; the second, 31 pounds 3 ounces, and the third, 31 pounds. During the brake test *C* the number of revolutions recorded was respectively 10,918, 10,916 and 10,919. The fuel consumption for the three hours was 31 pounds 6 ounces, 31 pounds 8 ounces and 31 pounds 4 ounces.

The following chemical computation was made in connection with test *C*, and is based on the analysis previously given, assuming that all of the oil was burned.

	Pounds per Hour	
Oxygen for hydrogen combustion	30.12	
Oxygen for carbon	71.95	
Total oxygen	102.07	
Air used for combustion		443.8
Excess air (165.2 per cent.)		733.2
Hydrogen burned		3.765
Carbon burned		26.983
		1207.748

For comparison with other pump tests the duty per 1,000,000 B.t.u. is given. This duty is, however, based on the heat units in the oil and should therefore not be compared with the heat units delivered to a steam engine in the steam, as is customary with a steam pumping engine, but with the fuel burned under the boiler.

It may be interesting to compare this duty with that obtained by Professor Denton in his test of the Laketon pumping engine,* as oil fuel was used during that test. The fuel used at Laketon contained, by Professor Sherman's formula, 19,770 B.t.u. The evaporation in test 5 was 16.64 pounds from and at 212 degrees. This makes the boiler efficiency 81.3 per cent. The engine performance

*Abstract of a paper read before the American Society of Mechanical Engineers, December, 1911.

†This engine was fully described in Power for January 25, 1910.

*American Chemical Society, Volume 30, October, 1908.

**Transactions* American Society of Mechanical Engineers, Volume 14, pages 1349 and 1373.

RESULTS OF TESTS

Test	A	B	C
Start	9:00 a.m.	2:00 p.m.	9:00 a.m.
End	12:00 m.	5:00 p.m.	12:00 m.
Average revolutions per minute	181.528	182.5	181.96
Average m.e.p.,* lb. per sq.in	86.14	65.6	65.85
Average i.h.p.*	123.14	94.2	93.36
Average brake horsepower	85.86	64.57†	64.68
Pressure pumped against lb. per sq.in		570.00	
Average gage barrels per hour		256.38	
Pump h.p. by piston displacement		60.143	
Pump h.p. by actual gage bbl. pumped		54.48	

FUEL CONSUMPTION

Test	A	B	C
Lb. of fuel per hr	42.77	31.1041	31.375
Lb. of fuel per i.h.p.-hr	0.347	0.331	0.333
Lb. of fuel per b.h.p.-hr	0.498	0.482	0.485
Lb. of fuel per pump h.p.-hr. by displacement		0.5171	
Lb. of fuel per pump h.p.-hr. by gage barrel		0.524	

EXHAUST

Test	A	B	C
Temperature of gases, Fahrenheit	678	483	485
Average analyses:			
CO_2, per cent	7.77	5.37	5.44
O, per cent	10.17	13.5	13.24
N, per cent	82.06	81.13	81.32
Specific heat	0.2393	0.2388	0.2387
Amount of gases, pounds per hour:			
By calculation of displacement at 70 deg. Fahr.	1455.00	1500.00	1491.00
If temperature were same as jacket water	1181.00		1220.00
From chemical test			1208.00

JACKET WATER
(Capacity of tank 39.429 gallons per inch depth)

Test	A		C
Inches used from tank	18		$12\frac{7}{16}$
Total gallons used	709.7		490.4
Average pounds per hr	1971.0		1362.0
Average pounds per b.h.p.-hr	22.97		21.05
Average inlet temperature, Fahr	68.7		71.3
Average outlet temperature	193.3		187.8

HEAT BALANCES

Test	A	B	C
Input, B.t.u. per hour	815,153	592,813	597,976
Engine useful work: B.t.u. per hour	218,514	164,331	164,610
Per cent	26.8	27.75	27.52
Loss in cooling water: B.t.u. per hour	246,375		158,673
Per cent	30.2		26.5
Loss in exhaust: B.t.u. per hour			119,520
Per cent			20.03
Loss in friction and radiation by difference:			
B.t.u. per hour			155,173
Per cent			25.95
B.t.u. per hr. in cylinder work	313,391	239,739	240,046
B.t.u. per hr. in useful pump work, output of station		151,376	
B.t.u., input per b.h.p.-hr	9,491	9,186†	9,244
B.t.u. input per pump h.p.-hr		9,987	
Duty, ft.-lb. per 1,000,000 B.t.u. (based on oil pumped per actual gage)		198,664,000	

EFFICIENCIES

Test	A	B	C
Engine: Indicated heat eff., per cent	38.4	40.45	40.2
Mechanical efficiency	69.71	68.55‡	68.55
Brake heat efficiency	26.8	27.75	27.52
Pump: Volumetric efficiency, per cent		98.9	
Pump and transmission, per cent		92.1	

LUBRICATION

Test	A	B	C
Cylinder oil: Lb. per hr		0.6875	0.9375
Lb. per 100 b.h.p.-hr		1.0625	1.445
Engine oil: Lb. per hr		1.78	1.16
Lb. per 100 b.h.p.-hr		2.76	1.795

FUEL OIL (Illinois Crude Oil)

Baumé, 33 deg. = specific gravity 0.863
Flash point, 35 deg. Fahr.; burning point ..... 65 deg. Fahr.
Heat value, 19,059 B.t.u. per lb. by test; 19,570 by Sherman's formula.

*Probably high, due to the momentum of indicator parts. This accounts for comparatively low mechanical efficiency shown in the efficiency table.
†Computed.
‡Assumed same as in test *C*.

was 124,375,834 foot-pounds per 1,000,000 B.t.u., or 15.985 per cent., and the total efficiency of the plant was 13 per cent., as against 25.52 per cent. for the plant, which was the subject of the present tests.

Fig. 1 shows a typical indicator diagram for tests *B* and *C*. The compression pressure was 347 pounds per square inch. The average drop in speed from no load to full load was 4 revolutions per minute, the speed range being 182 to 186 revolutions per minute. The other principal results of the tests are given in the accompanying tables.

Clean Blast Furnace Gas

The gas-cleansing plant at the Central Furnaces of the American Steel and Wire Company appears to be particularly efficient. We are informed that gas containing 1⅓ grains of flue dust at the entrance to the "clean gas" washer is delivered to the engines with only 0.0185 of a grain per cubic foot. The gas passes first through the usual dust-catcher, then through the "clean gas" washer, a wet scrubber of tower form in which it is given a whirling motion, then successively through a baffle washer, a Zschocke washer and a Theisen washer. The following are representative analyses "before and after":

	Raw Gas	Engine Gas
CO	26.3	26.4
H	2.7	2.9
CH_4	0.22	0.22
CO_2	12.9	13.0
N	57.52	57.08
O	0.36	0.40
	100.00	100.00
B.t.u. per cubic foot { computed		101.1
B.t.u. per cubic foot { by test		93.8
Grains moisture per cubic foot		0.528

CORRESPONDENCE

Mr. Rice's Producer Plant

A. A. Rice, discussing in the October 31 issue the coal consumption of his producer-gas plant, states that his fuel (buckwheat) is of very poor quality. In forming an estimate of what a plant should do, the quality of the coal goes a long way; if the heat units are not in the coal you cannot possibly get them out of the gas and must consume more fuel than with a coal of a higher heat value. It is sometimes true, however, that the coal which is the highest in B.t.u. does not work the best in a gas producer; I have seen a poor coal give good working results inside the producer.

The coal consumption depends a great deal also on the load on the engines; I have found that an increase from three-quarters to full load has very little effect on the coal consumption.

I should estimate that Mr. Rice's plant ought to consume on the average about 1200 to 1500 pounds per day, standby losses included.

Mr. Rice states that there is a little

leakage around the engine piston; this is generally the case with large horizontal gas engines, as there is a high pressure in the cylinder immediately after ignition. If the rings are not worn too much, giving the piston and rings a good dose of kerosene when standing after a run helps the rings quite a lot; it relieves them from stickiness by cutting out any carbon and dirt that may be in the grooves and also keeps the combustion chamber free from carbon deposit, especially on the bottom of the cylinder, where it has the habit of forming at the end of the piston's travel.

On starting up after the standby over Sunday I always give the pistons a dose of kerosene and oil and when the compressed air is turned on the engines turn over as freely as if starting up just after completing a run.

I should not think that speeding the engines up would give a lower coal consumption; they should be run at the speed that they were designed for by the maker.

As to the temperature of the gas, I should say that if it is cool* when leaving the scrubber it would be all right. If the gas is not properly cooled, vapor will condense in the gas piping and if the line is not fitted with a trap or drain the accumulation of water will cause trouble. Moreover, a greater weight of gas will be taken into the cylinder if it is cold.

Sometimes there is much difficulty in getting the gas cooled, no matter how much water goes through the scrubber. This is generally the fault of the generator. If it becomes badly clinkered around the sides, reducing the active area of the fuel bed, the increased intensity of draft will raise the fire level above the proper combustion zone, reducing the body of coal available to absorb heat and increasing the gas temperature. In some extreme cases, air from the ashpit will pass up around the clinker without passing through the fire, and mix with the gas above the fuel bed and cause it to ignite there. There will be great difficulty in cooling the resulting mixture of fresh and partially burnt gases, and, of course, the engine will not pull its load if the load is near the producer's limit.

S. G. Rose.

Brockville, Ont.

In his letter of October 31, Mr. Rice does not say whether his producer is of the suction or the pressure type; this would have some bearing on the fuel consumption. The generator driven by the 100-horsepower engine probably has an efficiency of about 88 per cent. at the rate of working (50 kilowatts average load), which would mean a brake load of about 76 horsepower on the engine, or practically three-quarters of its rating. With such a load factor I should say that with good coal a consumption of 2 pounds per brake horsepower-hour would be about right, with 100 pounds extra for keeping the fire over night and another 100 pounds for Sunday.

I am judging from results obtained in our own plant. We have two 250-horsepower pressure producers, two 125-horsepower and one 160-horsepower engines, direct-connected to electric generators. Steam is supplied by two small boilers for the producer generators. The load factor on the electric generators is 60 to 70 per cent. The plant runs 24 hours a day, 10 months of the year. The producer fuel is anthracite pea and the average consumption is 2.4 to 2.7 pounds of pea coal and 0.3 to 0.4 pound of soft coal (under the boilers) per kilowatt-hour.

J. H. Lenoir.

Keene, N. H.

*Any temperature within 30 degrees (F.) of the atmosphere may be considered "cool." —Editor.

Timing the Ignition

The following method of timing the ignition of gas engines and checking up the time of ignition at frequent intervals will be found both convenient and sufficient.

Make a tram of such length that when one end rests on the floor the other end will be exactly opposite the center of the crank shaft (see Fig. 1). Put the engine on the inner dead center and set the tram at the rim of the flywheel; make a center-punch mark in the rim opposite the end of the tram, so that it will be the same distance from the floor that the center of the crank shaft is. It is well to make a punch mark also in the floor at the point where the tram is set, for future checking.

Measure from the mark on the wheel, around the rim in the direction the wheel is to run, the distance ahead of the center that the engine is to fire and make another punch mark at this point. The igniter should trip when the flywheel is in such a position that one end of the tram will coincide with this point when the other end is on the mark on the floor.

The distance by which an engine should fire ahead of the dead center is usually stated in degrees. To find the corresponding distance in inches it is only necessary to multiply the number of degrees by the circumference of the wheel in inches and divide the product by 360.

For example, suppose the flywheel is 10 feet in diameter and the engine is to fire 20 degrees ahead of the dead center. The circumference of the flywheel is $10 \times 3.1416 \times 12 = 377$ inches. Multiplying this by 20 (degrees) and dividing by 360 gives 20.94 inches for the distance between the dead-center mark on the flywheel and the mark that should be opposite the tram at the instant of tripping.

If the engine works on the four-stroke cycle, care must be taken to see that

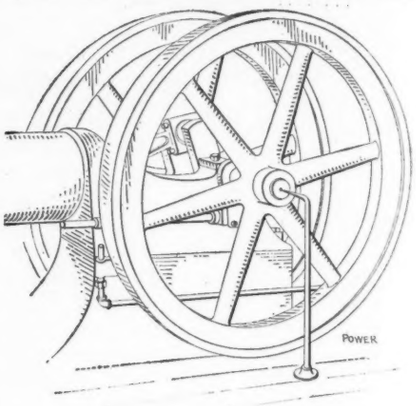


Fig. 1. Proper Hight of Tram

ignition occurs on the proper stroke; that is, near the end of the compression stroke.

Earl Pagett.

Coffeyville, Kan.

Sulphur in Gases

I was very much interested in reading in the November 14 issue the article by Olaf Olafsen on the effects of sulphur in fuel oil or gas, and wish to add slightly to his comments. He calls attention to the effects of water in the engine in connection with the sulphur, which may be in either the oil or gas, this water turning the sulphurous anhydride into sulphuric acid, which acts very vigorously on all parts of the engine with which it comes in contact. He does not, however, refer to the difficulties which are often encountered in the exhaust passages and pipes, particularly those of the outboard exhaust.

It is not infrequent to find that the exhaust of an oil or a gas engine is noisy and very troublesome to the people in the immediate vicinity of the plant; and in order to avoid this noise, water is sometimes injected into the gases for the purpose of cooling them more rapidly and thereby reducing the pressure and noise. Under these conditions also, the sulphur in the gas or oil helps to form sulphuric acid, and unless particular attention is paid to the material of which the exhaust pipes is made, they are very quickly eaten out. Various schemes have been tried to avoid this difficulty, among them being the use of earthen pipes and also the delivery of the exhaust directly into a pit filled with large stones, thereby doing away with the use of water. My particular reason for writing is to call attention to the advisability of avoiding the use of metallic exhaust pipes in case water is used for cooling the gases, or if water is used and the gas happens to contain sulphur.

Henry D. Jackson.

Boston, Mass.

Refrigeration Department

Principles and operation of ice making and refrigerating plant and machinery

Cooling Public Buildings

By Fred Ophüls

In the November 28 issue of Power an article by E. F. Tweedy gives a correct account of the present state of the art of refrigeration as applied to the cooling of public buildings and concludes with some calculations, the final results of which give the refrigerating effect required to cool a theater or lecture room 100 feet square and 30 feet high to 75 degrees Fahrenheit, when it is occupied by an audience of 500 people, the humidity of the air not to exceed 60 per cent. at this temperature and the circulation of the air to be at the rate of five complete changes per hour to afford the proper purity for healthy living. The maximum temperature in the shade was assumed to be 90 degrees Fahrenheit and the relative humidity 80 per cent.

To fulfil these requirements refrigeration at the rate of 246 tons per hour was found to be necessary. No figures are given showing what such an installation would cost or what the operating expenses would be.

The artificial cooling of buildings of this character is at all times of great interest and many schemes have been devised and patented and some apparatus installed in hotels and public buildings for this purpose. The water principally used in these plants to cool and purify the air is secured either from wells on the premises or from the city supply. While the best of these apparatus secure at times quite a reduction in the temperature of the air—and, of course, clean it of most of the solid matter in suspension and the gases soluble in it—the great drawback of these plants is the excessive humidity at times of the air so treated, which either produces a sensation of cold or oppressive heat on account of insufficient evaporation of moisture from the body.

These facts led to the use of refrigerating machines to cool and dry the air at the same time. The results of plants of this kind have not been as satisfactory as could be desired on account of the excessive first cost of the installation, the high operating expenses and the extreme temperature reductions sought. If a 200-ton refrigerating machine or its equivalent must be used to properly cool an auditorium holding only 500 people, the installation of such a system cannot be considered. Furthermore, it has been found that a reduction of from 15 to 20 degrees in the temperature of a room in summer will be very unpleasant to those staying in it for any length of time, as the body becomes rapidly chilled. It seems therefore that this problem must be taken hold of in a somewhat different manner.

People in extremely hot climates, where the temperature is 100 or even 110 degrees in the shade, do not suffer as much from the effects of heat when the atmosphere is very dry as people do in New York and other cities similarly located when the thermometer registers only 90 degrees in the shade and the relative humidity is high. The conclusion derived from these facts is that the relative humidity of the air plays an important part in this problem and if it is maintained at the proper point an actual reduction of temperature may not be necessary.

Investigations should be made to determine for each degree of temperature the relative humidity necessary for the most comfortable living.

Experiments on these lines are being made by the municipal departments of some of the cities which have charge of the public schools. The ultimate solution of the proper ventilating and humidifying of the air in all public places will most likely be found in the installation of a combined air-purifying and drying plant using water for purifying and some cooling and mechanical refrigeration for drying the air. It is also interesting to determine whether, by the use of mechanical refrigeration alone, a system can be devised that will produce the desired results at reasonable first cost and operating expenses. It is the purpose of this article to present some calculations based on such a system, assuming that the main object is to reduce the relative humidity of the air to the proper point.

Instead of cooling the air to a point so that the resulting temperature in the auditorium will be 75 degrees Fahrenheit, assume that for comfortable living the moisture in the air should not exceed 4.437 grains per cubic foot and that the air entering with this content of moisture need not be more than 5 degrees Fahrenheit lower in temperature than the outer air in the shade. The quantity of air to be circulated is governed by the maximum weight of carbon dioxide which the air is allowed to contain when discharged from the building. For these calculations assume that the air leaving should not contain more than 0.105 per cent. of carbon dioxide, the initial contents being 0.06 per cent. The most adverse atmospheric conditions, in the locality of New York, are a temperature of about 90 degrees in the shade and 8.874 grains of moisture per cubic foot of air. The auditorium is to be used for theatrical or other similar purposes twice a day, each session lasting three hours, allowance to be made for rehearsals, cleaning, etc.

An adult person exhales on an average 0.11 pound of carbon dioxide per hour—this will be 55 pounds for 500 people. Each 100 pounds of air can take up 0.045 pound of carbon dioxide before it contains 0.105 pound and therefore 122,000 pounds of air must be supplied per hour for 500 persons.

To reduce the moisture contents of the air from 8.874 to 4.437 grains the air must be cooled to about 53 degrees Fahrenehit. The required refrigerating effect is figured as follows:

	Bt.u. per hour
Condensing and cooling 1132 pounds of moisture	1,245,200
Reducing the air from 90 to 53 degrees Fahrenheit	1,074,332
Total	2,319,532

By the use of an interchanger, the refrigerated air leaving the cooler at 53 degrees can be heated by the entering fresh air to 85 degrees so that the net refrigerating effect required is 1,390,000 B.t.u. per hour.

Figuring further that, during rehearsals and when cleaning, at least 30 persons are busy in the auditorium, and that the refrigerating plant is so constructed that it can operate at maximum capacity continuously and store up the refrigerating effect during the time when little or none is required, the total refrigerating effect under these conditions will be 14,687,400 B.t.u. per 24 hours, which is equivalent to 50 tons of ice-melting capacity per 24 hours. Allowing 10 per cent. for heat leakage and other losses gives a total of 55 tons of actual refrigeration required per 24 hours.

A 55-ton refrigerating system with motor drive, condensers, cooling plant,

pumps, blowers, interchanger, air ducts and all piping and connections will cost approximately $12,000, and the operating expenses per day of 24 hours, above those of running the power plant of the house and when operating at average capacity, will not be over $36 per day. The charges for depreciation, interest on investment, taxes and insurance will be $1800 per year. Basing the per capita charge for these expenses on an average of 50 per cent. of the total seating capacity of the auditorium and that the refrigerating plant will be operated 120 days per year, the total expense will be $6120 per year or about 4 cents per person.

The total cost of operating such plants naturally decreases with an increase in the seating capacity of the house as well as with an increase in the number and length of the performances per day.

Taking, for example, a motion-picture or continuous-performance theater, seating about 1000 persons, in which are given each day six sessions of two hours each, the operating expenses, including all fixed charges, would not exceed 2.3 cents per capita, based on the attendance during the four summer months only, and 1.67 cents per capita for the attendance of the whole year.

Russians to Adopt American Railroad Refrigerating System

To investigate the system employed for the precooling and icing of perishable products by American railroads, and to gather data on the types of refrigerating cars now in use in this country, representatives of the private railroads of Russia were at San Bernardino, Cal., inspecting the precooling methods of the Santa Fé Railroad Company. The party consisted of Constantin Tihotsky, manager of the transportation committee of St. Petersburg; Oscar Dreier, traffic manager of the Riasano Ooralsk Railway, in southern Russia, and M. Krassovsky, assistant general superintendent of motive power of the Moscow-Kazan Railway.

Congress of Refrigeration Industries

The third international Congress of Refrigerating Industries will be held at Chicago, 1913. It will be divided into sections for the discussion of the various branches dealing with the technical features of refrigeration, food products, legislation, precooling and transportation, and other sections of the work.

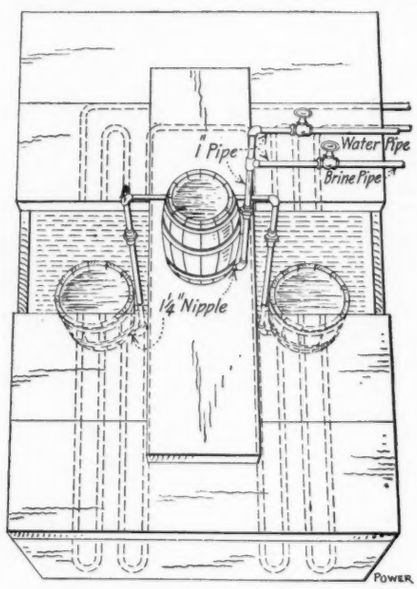
The first congress was held at Paris, in 1908, under the auspices of the French government; the second, in 1910, at Vienna, with the support of the Austrian government, at which time President Taft extended the invitation to hold the third meeting in America. Engineers and government officials from all parts of the world interested in the industry will attend.

Appointment is announced of G. Harold Powell, of Los Angeles, Cal., for several years in charge of investigations of cold-storage and refrigerating transportation of the Department of Agriculture, as first vice-president of the third congress. The active president has not yet been announced. Secretary of Agriculture Wilson is honorary president of the congress.

LETTERS

Homemade Outfit to Make Calcium Chloride Brine

To begin with, two coal-oil, or regular oil, barrels, of which one is sawed in half to make two tubs, are cleaned with boiling water, containing soda, until freed from oil. The accompanying figure



CALCIUM CHLORIDE BRINE OUTFIT

shows the cover of a brine tank. One section has been taken off and laid lengthwise of the tank; on either side of this cover the ammonia coils in the tank can be seen. On the sides of both tubs near the bottoms, holes are bored for 1¼-inch nipples, and the tubs are then set on the ammonia coils. In the barrel near the upper end, two holes are bored diametrically opposite for two 1-inch nipples. Near the bottom of the barrel another hole is made large enough for a 1¼-inch nipple. The barrel is then set on top of the section of the covers which lies across the opening of the tank. The barrel and tubs are then connected and a water and brine pipe connection made with the nipple near the bottom of the barrel.

Calcium chloride generally comes in one solid lump in large cylinders made out of black iron. With a hatchet, cut the top and bottom of the cylinder and break up the contents with a sledge. Then fill the barrel and tubs with the pieces and turn on the water. When enough water has flowed into the barrel, shut off the supply and turn on the brine.

The same arrangement may be used for making salty brine with the exception that the salt is put in the barrel only.

WILLIAM L. KEIL.

Philadelphia, Penn.

Temperature of Ammonia Discharge Pipe

I noticed that in a recent issue, T. L. D. asked if the discharge pipe of his ammonia compressor was too hot when it would boil water dripped upon it. The answer was made that under a working pressure of 185 pounds, 250 degrees Fahrenheit was not too hot for continuous operation.

It would seem to me that it depends almost altogether on the kind of compressor being used, whether it is a dry- or wet-gas machine and on the quantity and temperature of the condensing water available. For a dry-gas machine working under a head pressure of 185 pounds, 250 degrees Fahrenheit is about right. But I believe most of the wet-gas machine builders, and especially the Fred W. Wolf Company, recommend from 90 to 100 degrees for the discharge pipe working under a head pressure of 150 to 180 pounds. I also believe that when ammonia gas is heated beyond 100 degrees Fahrenheit that it will disintegrate; at least this has been my experience, and I have operated both kinds of machines. I would be pleased to hear from other operating engineers on this subject.

D. E. ADEN.

Wilburton, Okla.

Repairs to an Ice Plant

About two months ago I took charge of a 25-ton ice plant which was in operation but was not turning out any ice. The compressor was working one-sided so I took out the piston and found one ring broken and a part of the bottom of the piston broken off and lying in the bottom of the cylinder. This had caused the piston to work loose on the rod and gave it movement enough to slip up and hold the suction valve open when it should have been closed for compression. Consequently, the ammonia gas blew back into the suction side, causing the suction pipe to get nearly as hot as the discharge pipe. After putting in a new piston rod and a new ring on the piston, the compressor worked as well as a new one.

WALTER CARR.

Carmi, Ill.

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POWER

Safety Appliances

Whether the pressure carried be high or low as the terms are understood, it would not be considered good practice to operate a steam boiler without a safety valve, nor would such operation be permitted in many parts of the country.

Safety valves are used to prevent the rise of pressure in boilers above a predetermined point, by opening when that point is reached and allowing the escape of the steam, which, if retained in the boiler, would cause a rise in pressure above the point desired and perhaps dangerously stress the material of the boiler if it did not cause an explosion.

There is always a steam gage used in connection with the safety valve, each serving to check the other, and when any marked difference appears both should be tested and the discrepancy corrected.

No level-headed business man nor any intelligent engineer would contemplate running a boiler continuously with only a safety valve or a steam gage. Both would be used.

When it comes to the other apparatus in the plant, a different attitude is sometimes assumed. Steam-engine governors are used for the double purpose of keeping the engine running with a reasonable regularity of speed while carrying a load, and preventing an undue rise in this speed if for any cause the load is removed.

It often happens, however, that, through misunderstanding some of the functions of a steam-engine governor, the attendant makes alterations which throw it out of adjustment and make it so nearly inoperative for certain conditions as to be, instead of a governor, an element of danger.

Almost daily reports of flywheel accidents show that there is need that in connection with the ordinary steam-engine governor there should be applied a speed-limiting device which would shut off the steam supply whenever the speed of the engine exceeded a predetermined number of revolutions per minute.

Boilers furnished with safety valves and steam gages sometimes fail, but the number of failures would probably be much greater were either omitted from the equipment. So, too, an engine protected against excessive speed by an independent speed-limit safety stop might under some possible conditions run away, but the probability would be so greatly reduced that flywheel explosions would be almost eliminated from the list of industrial accidents.

As the safety valve and the steam gage are, for obvious reasons, both used on a boiler where either might possibly be made to serve the purpose without the other, so it would seem that even mediocre business judgment would dictate the use of a speed limit and safety stop in conjunction with the steam-engine governor.

Water Vapor in Air

Ordinary atmospheric air always has mixed with it some water vapor, which may vary from a very little in cool, dry weather to a much greater quantity in warm and damp weather. For sanitary reasons, as in heating and ventilation and for many industrial purposes, the measurement of this vapor content and its artificial regulation are matters of importance to engineers.

In general, the quantitative composition of a mixture of gases can be found only by chemical analysis. But when one component is a slightly superheated vapor, easily lowered to its temperature of saturation or of incipient liquefaction, a simple physical determination of its amount is possible. At saturation, characteristic pressure and specific volume are both fixed by temperature alone. Further, a given space will contain the same weight of vapor whether this exists by itself, with its own pressure only, or whether it is diffused through a larger

mass of gas, under the higher combined pressure due to vapor plus gas. If the "air" in a unit of volume is partly vapor of water, there will be fewer oxygen and nitrogen molecules than if no steam molecules were present.

Air carries its maximum content of vapor when the latter is in the state of saturated steam, ready to begin to condense on the least abstraction of heat; and the air itself is then said to be saturated with vapor. If less vapor is present, it may be considered as having been superheated from some lower temperature of saturation, under the pressure belonging to that temperature. Since vapor tension or saturation pressure rises with temperature, so does also the weight of vapor which a given weight of pure air can carry.

On these principles of thermal physics are based two methods of vapor determination. By slowly cooling a polished-metal surface and observing the temperature at which it just begins to be clouded with condensed vapor, the dew point or temperature of saturation for the actual atmosphere is found. The weight of a cubic foot of saturated steam at this temperature measures absolute vapor content or humidity, to be compared with the possible content at the higher prevalent temperature in order to get relative humidity.

Again, when water and nonsaturated air are in contact, vapor tends to be formed until the air becomes saturated. Vaporization absorbs heat, which may come from several sources, as from the air or water or from the surrounding bodies. If an original air and vapor mixture is the only source of heat, evaporation of enough vapor to saturate it will produce a definite degree of cooling. Practically, a current of air is blown over the wetted surface of a sheathing of cotton wicking wrapped around the bulb of a thermometer. After a short time for the establishment of stable conditions, this wet bulb will be lowered to a temperature such that the latent heat of the vapor formed will equal the sensible heat lost by as much of the air current as would be saturated by this vapor, at the temperature of formation of the latter, or of the water. Since the sample of air takes up vapor in addition to its original content, wet-bulb temperature is higher than dew point.

The wet-bulb apparatus is called a psychrometer. In a paper by W. H. Carrier, on "A Rational Psychrometric Formula," presented at the recent annual meeting of the American Society of Mechanical Engineers, the thermal relations involved in the action just described are clearly developed, and by means of charts are put into shape for convenient use. To the ideal operation of saturating air by vapor formed wholly at the expense of its own sensible heat, Mr. Carrier gives the convenient and accurately descriptive title of "adiabatic saturation."

The effects of humidity and the problems of air conditioning may now be briefly suggested.

The dew-point idea, in excess, is illustrated by the sweating of cold-water pipes, etc., in summer, and by the condensation on the windows of warm and moist rooms in winter.

The wet-bulb idea is best exemplified in the drying kiln, as for drying lumber. Heat to vaporize the moisture in the wood comes almost wholly from the hot air blown into the kiln, so that this air is subjected very nearly to adiabatic saturation.

In the cooling tower, on the other hand, evaporation is induced by air currents, but latent heat is supplied by the descending stream of warm water, intended to be cooled by this action. Consequently, the saturation capacity is that of air at but little less than the initial temperature of the warm water.

In heating and ventilation, the problem is to add vapor to winter air, which is made excessively dry and thirsty by raising it to indoor temperature; of course, the formation and heating of this vapor is an added burden on the heat supply. If air is cooled for summer ventilation, some of the vapor already present must be removed, most readily by supercooling, condensation and separation, to be followed by a partial reheating of the air.

When humid air is compressed, and after the heat of compression has been dissipated, most of the original vapor content is precipitated; as the total pressure is greater, the vapor tension (although absolutely the same for a given temperature) becomes relatively less, with a resulting decrease in the weight of air that can be carried by a unit of dry air. Unless the air is cooled near the compressor and the water is precipitated, there will be an accumulation in the pipes, with possible freeze-ups in winter, and perhaps trouble with the tools and the machines using the air.

In the operation of the blast furnace, dry air is most desirable, since water vapor is dissociated in the very hot zone just within the tuyeres, absorbing heat which is there much needed for the metallurgical reactions; hence the recent, most advanced scheme of refrigerating and thus drying the blast between blowing engines and blast ovens.

In all the examples so far cited, the vapor tension and the quantity are relatively small, but at the low pressures in steam-engine condensers, vapor volume is of the same order of magnitude as air volume, in a saturated mixture. For better effect in maintaining vacuum, modern condensers are so arranged as to produce localized and progressive cooling toward the outlet to the air pump, thus diminishing the proportion of vapor and the total volume of the mixture going to the air pump.

In our issue of November 7, we were made to say that only the gravity underfeed stoker could carry an overload of fifty per cent. continuously. It was the publicity man of the gravity underfeed stoker who furnished the test results under consideration, and he slipped one over on the man at the editorial bat by getting through, along with them, the above observation. We apologize to the other stokers and—as for that pitcher, wait until he gets into the box again.

Engineers are put on guard against a new sort of explosion by an accident which occurred recently at the Ayer mill in Lawrence. In the overhead coal storage is a concrete ash bunker, in the form of an inverted pyramid some fifty feet across, made sufficiently air tight to allow a vacuum of fourteen inches of water to be maintained in it. Into this the ashes are drawn by suction from the ashpits. Some weeks since an explosive mixture of gas was drawn over from the boilers or generated from the ashpit refuse which became ignited in the bunker and exploded with considerable violence.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Underfeed Stoking vs. Overburning

During a recent national convention of smoke inspectors, one of the members took the position that to obtain the best smokeless conditions, "underfeed stoking" was necessary. Feeling that I could not permit his statements to go unchallenged, I ventured a few remarks and it developed that what the gentleman intended to say was not "underfeeding" to produce smokeless combustion but "overburning," as he termed it, which might be construed as two quite different processes and yet after all that was said, many of those present were left with a cloudy impression of what was really intended.

It is impossible to get perfect combustion and maximum temperature under a boiler by feeding coal up from below and forcing air up through the incandescent mass of fuel, although it is possible to obtain high temperatures in the mass of fuel itself.

I recently came across a work written by George B. N. Tower, formerly chief engineer of the United States Navy. This book, written many years ago, is full of the chemistry of combustion. Among Mr. Tower's many deductions I find that some are exactly to the points I raise against underfeed stoking, producing as it does a deep fire above the tuyeres and driven by a forced blast from below.

Mr. Tower says the direct effect of the union of carbon and oxygen is the formation of carbon dioxide. If, however, one of its portions of oxygen is abstracted, the remaining proportions would be those of carbonic oxide. It is equally clear, however, that if a second portion of carbon is added to carbon dioxide, the same result will be had, namely, the having carbon and oxygen combined in equal proportions, as is seen in the case of carbonic oxide.

Now, if these two volumes of carbonic oxide cannot find the oxygen required to complete their combustion, they pass away necessarily but half consumed, a circumstance which is constantly taking place in all furnaces where the air has to pass through a body of incandescent carbonaceous matter.

The most prevalent operation of the furnace, however, and by which the largest quantity is lost in the shape of carbonic oxide is thus: The air on entering from the ashpit gives out its oxygen to the glowing carbon on the bars and generates much heat in the formation of carbon dioxide. This gas, necessarily at a very high temperature, passing upward through the body of incandescent solid matter, takes up an additional portion of the carbon and becomes carbonic oxide.

Thus, by the conversion of one volume of dioxide into two volumes of oxide, heat is actually absorbed, while also the portion of carbon taken up during such conversion is lost, and one is deceived by imagining that the "smoke has been burned."

Smoke is a sure evidence of imperfect combustion; but, it does not necessarily follow that where there is no smoke combustion is perfect.

Mr. Tower quotes from Professor Daniell, of England, as follows:

"Any method of insuring the complete combustion of fuel, consisting partly of the volatile hydrocarbons (compounds of carbon and hydrogen) must be founded upon the principle of producing an intimate mixture with them of air in excess in that part of the furnace to which they naturally rise."

To bring the coal, in both its solid and gaseous elements, into intimate mixture with air, and to ignite the compound, are all that human means can accomplish—Nature only, in her own processes, effecting the rest. The distilation of gas, when fresh coal is supplied, goes on near the surface of the fire; the gas naturally burns above the surface, and the air necessary for its combustion must be admitted, therefore, above the surface.

The question is often asked: "Why not provide at once for the admission, through the grate, of sufficient air both for the coke and the gas?" This would be an impossibility, for whatever the quantity of air admitted through the grate, it will expend itself on the coke only—at least until holes are burned through the fire; then the control of the air is at once lost, and great waste of fuel ensues.

The admission of air above the fire must be in the greatest practical number of small jets, since gas and air mix only gradually, excepting by division and inducement. Air, in bulk, mixes only superficially with gas, and by abstracting heat cools the furnace. The air ports should be placed as near as practicable to where the gases rise, since, after they are disengaged from the coal, it is necessary to commence their combustion at the earliest moment. Gases, to be thoroughly burned in the furnace, must be intercepted by air at the start, else the combination, which is at best gradual, will not be completed in season, as what remains uncombined on reaching the tubes is lost.

There is a great difference between anthracite and bituminous coals. Anthracite burns completely with a thin fire, by admitting an excess of air through it and above it; but bituminous coal absolutely requires for its perfect combustion a high temperature and plenty of room for the products of combustion, before they come into contact with the iron of the boiler, together with a proper supply of air above the fuel. Any deviation from these conditions produces smoke and loss of heat.

Orosco C. Woolson.

New York City.

Took Gases from the Uptake

Some time ago I had a good demonstration on chimney waste in burning coal. I was using No. 2 buckwheat mixed with soft coal in proportion of one to seven, just enough to give body and not smoke. I used a patented steam blower for forced draft, and kept the damper open far enough to keep the flames from blowing out the fire doors.

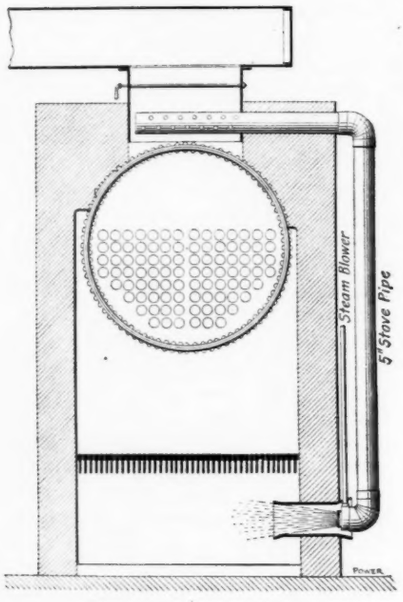
One day there was a slight explosion in the front connection and on opening the doors I found that a part of the arch had fallen out, making a short cut for the flames and the gas which burned in front of the tubes and toward the damper.

This occurred each time fresh coal was put on the fire, and continued until the fire burned up brightly. After the arch was repaired, I made a hole through the brickwork, as shown in the sketch, using ordinary 5-inch stovepipe. The bottom end just fitted in the steam ring of a blower, so that it drew the gases down into the ashpit, and so up through the fire.

Fresh air was drawn in around the side of the ring, and the changed furnace condition could readily be seen. On ac-

count of the shaking bars the ashpit could not be made air tight, so that each time fresh coal was put on the gases coming out were choking; but the brickwork in the combustion chamber got so red hot that I could see the rivets on the rear head of the boiler.

On testing with and without the gases being returned, I found the average evaporation without the return was 6.9 pounds



GAS BYPASS TO ASHPIT

of water per pound of coal, and with the return 7.9 pounds of water per pound of coal. On account of changing to soft coal shortly afterward I was not able to experiment further with the arrangement.

H. L. BRECKENRIDGE.

Belleville, N. J.

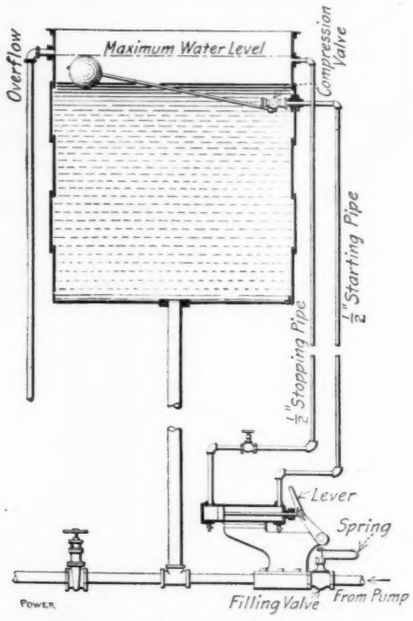
Controller for Water Tank

I have used several kinds of tank gages and have not found one that is reliable at any distance from the tank, so I have discontinued their use and constructed the device illustrated herewith.

The device is placed on the bypass or filling-pipe line. After the tank is once filled and the pipes connected, the water never gets below the compression cock or higher than the stopping pipe unless the tank is to be overflowed.

When the water in the tank gets down to the lower level or just above the compression cock, the ball float, having been set to open at this point, the water enters the cylinder through the starting pipe, pushing the piston and rod into the cylinder. This action partially turns the cam on the valve stem on the line leading from the pump, which is controlled by a pump governor. This opens the valve and the water is then pumped into the tank until it lifts the ball float which closes the compression cock. The water then continues to rise in the tank until it reaches the inlet of the stopping pipe and flowing to the cylinder reverses the action of the piston and lever which closes the filling valve on the discharge pipe from the pump.

The globe valve on the stopping pipe is only used to show that the tank is full. When testing, the globe valve is closed, and the piston is pushed in by



WATER TANK AND CONTROLLER

the lever. The tank will then fill to overflowing, and when the valve is opened, the filling valve will be closed as before. The globe valve should be left open at all other times.

In each end of the cylinder a small drain hole is drilled and fitted with a pet cock which is left open to drain the pipes as well as the cylinder. The size of the cylinder depends on the hight of the tank. I used a 3-inch brass tube on a 60-foot tank.

In adjusting the cam on the inlet valve, the large part of the cam should rest on the stem when the valve is closed; this prevents the valve opening when the cylinder is relieved of its pressure.

J. E. J. GOODLETT.

Memphis, Tenn.

Hump Caused Pound

It was a 17 and 34 by 42-inch engine, running at 104 revolutions per minute and developing about 400 indicated horsepower.

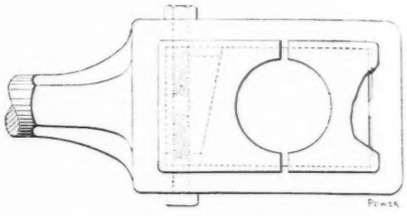
It ran from Monday morning until the next Sunday morning.

When the engine was first started after erecting, it had a slight pound, but the load was light and the connections were taken up two or three times a week so the erecting engineer got by all right.

But when more load came on, the engine pounded hard and the hunt began; and no matter where one listened, the pound seemed to be there.

Engineers from other plants gave their opinions, and their ideas were all tried out, but with no results.

One Sunday I disconnected the connecting rod from the crosshead, and found on the inside of the strap a hump



DEFECTIVE CRANK-ROD END

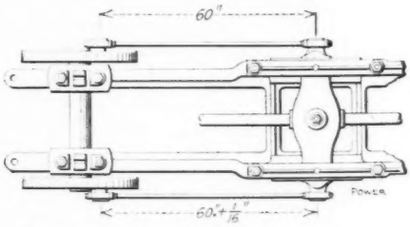
in the steel, as shown in the sketch. I smoothed the hump off, which was about 1/8 inch, connected the rod and when I started, Monday morning, the pound was gone. I cut the hump off about a year ago and the engine has not pounded since.

R. A. HAFFORD.

Groveton, N. H.

Knocking in Air Compressors

A double connecting-rod air compressor will frequently knock badly unless the air valves are in good condition and the steam valves are properly set. The knock is caused by the elastic spring of the air in the air cylinder acting against the steam piston when the steam is expanding, due to the cutoff. This trouble can be eliminated in part by setting the steam valves so as to allow plenty of steam to



DOUBLE CRANK COMPRESSOR OUT OF ADJUSTMENT

follow up the piston and not cut off too early.

Straight-line compressors should have the valves set on the steam end so that the air valve will be closed on the compressor end when the steam piston is nearing the end of its travel; otherwise the elastic body of air will cause a bad hammer.

Some knocks are caused by a wearing of the side-rod brasses. I have found them on double-rod machines so worn that one rod would be 1/16 inch longer than the other.

Sometimes the crank pins are not equally distant, as shown in the illustra-

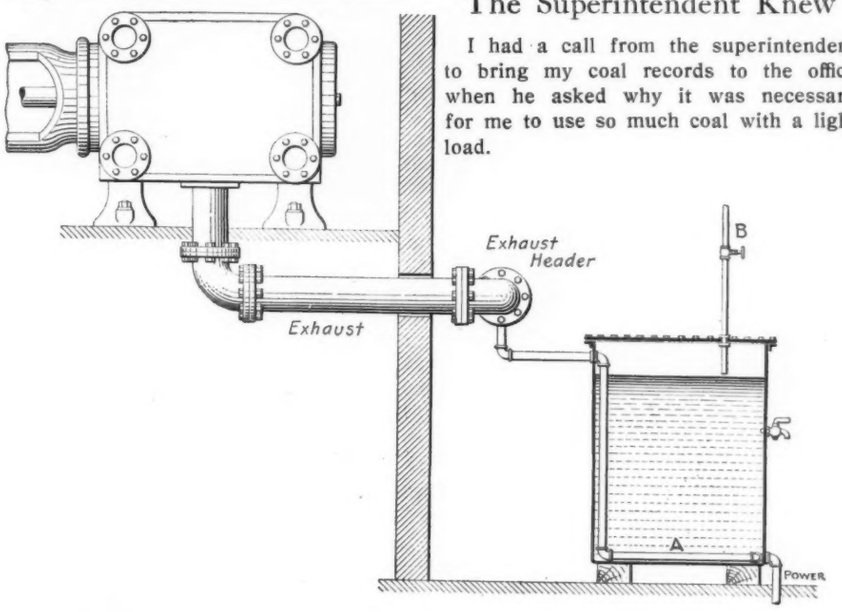
tion. New babbitt in the crank-shaft bearings or thin copper liners between the end of the connecting-rod brasses on the short-rod end would remedy the defect.

Baltimore, Md.

C. R. McGAHEY.

Hot Water Supply

A friend of mine who hates to see a heat unit wasted rigged up the outfit illustrated herewith. Originally the 1-inch drip from the exhaust pipe discharged direct into the sewer. He had an old closed steel tank about 4 feet square and he connected the drip as shown, *A* being a coil of 12 pipes wide laid upon the bottom of the tank and discharging into the sewer. The drip pipe keeps the water hot in the tank and it



ARRANGEMENT FOR HEATING WATER

can be drawn off for use at the faucet. The tank is refilled at any time from cold-water supply *B*. The water is absolutely clean as the tank has a good cover.

J. E. NOBLE.

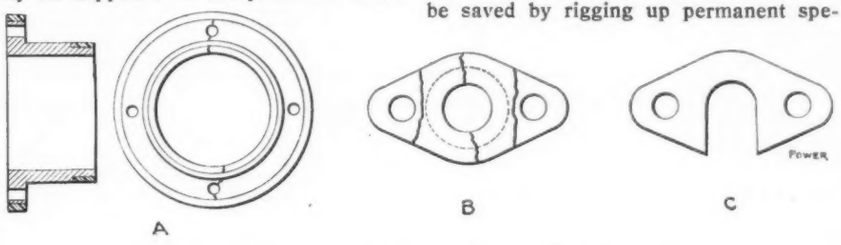
Toronto, Can.

Repairing Stuffing Box Gland

An engineer is not necessarily "up against it" because a stuffing-box gland breaks.

Large glands, such as are found on plunger pumps, may be repaired by shrinking a ring around the outside of the flange, and then turning down the boss and shrinking on a ring, as shown at *A*. Where appearance, or small clearance, prohibits an increase in the outside diameter of the cover, it can be clamped together temporarily, and turned down to the studbolt holes, the metal turned off being replaced by a ring.

Small gland covers can be repaired by placing a ring around the flange part, when broken as shown at *B*, or a plate can be cut as shown at *C*. This plate may be slipped over the piston or valve



METHOD OF REPAIRING BROKEN STUFFING-BOX GLANDS

rod, and held against the gland cover by the nuts of the gland studs.

W. E. BERTRAND.

Philadelphia, Penn.

The Superintendent Knew

I had a call from the superintendent to bring my coal records to the office when he asked why it was necessary for me to use so much coal with a light load.

I stated the number of pounds of water evaporated per pound of coal, and he went to work and wrote down a lot of formulas, but I doubt if he knew what they meant. However, after figuring for a while he said that I was not doing quite so badly as he thought; I was burning only 80 pounds of coal per horsepower per hour.

On another occasion it was necessary to operate the plant noncondensing. When I turned in my chart for the month the superintendent said: "Now, let us see how much more coal it takes to run high-pressure than it does condensing."

He went to work tracing the chart I gave him and finally said that it took only 700 pounds more, which did not offset the cost of the condensing system. I concluded that if he could not read a chart better than that, I would not tell him the difference.

E. W. ROTH.

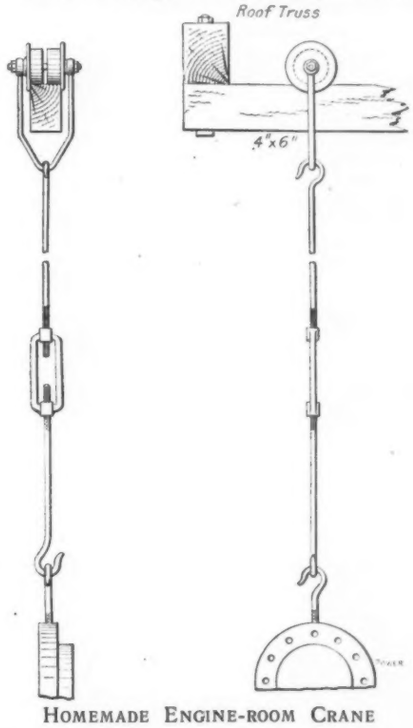
Chicago, Ill.

Engine Room Crane

In engine rooms where no traveling power crane is provided, much time can be saved by rigging up permanent special devices to lift and convey parts of machinery subject to repair and inspection.

The crane illustrated herewith is for removing cylinder heads, but is equally adaptable to the main journal and outboard-bearing caps or connecting rods and is so simple in construction that it can be made by any engineer out of otherwise useless material generally found around the plant.

The rail is made of a piece of 4x6-inch —timber stronger if necessary—bolted



HOMEMADE ENGINE-ROOM CRANE

up under the roof trusses in a position central to the work. The rollers can be made of flanged pulleys from an old rope-drive tension carriage, or a simple pulley; the width of the rail will do equally as well.

The outfit is completed by a ¾-inch round-iron axle supporting a clevis of the same material from which is suspended a hook rod with turnbuckle.

An arrangement of this kind makes frequent inspection of the piston rings and cylinder an easy task.

F. C. HOLLY.

Yazoo City, Miss.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Apparatus for Distilling Water

Some time ago August A. Specht asked for suggestions as to how he could get distilled water for his storage batteries.

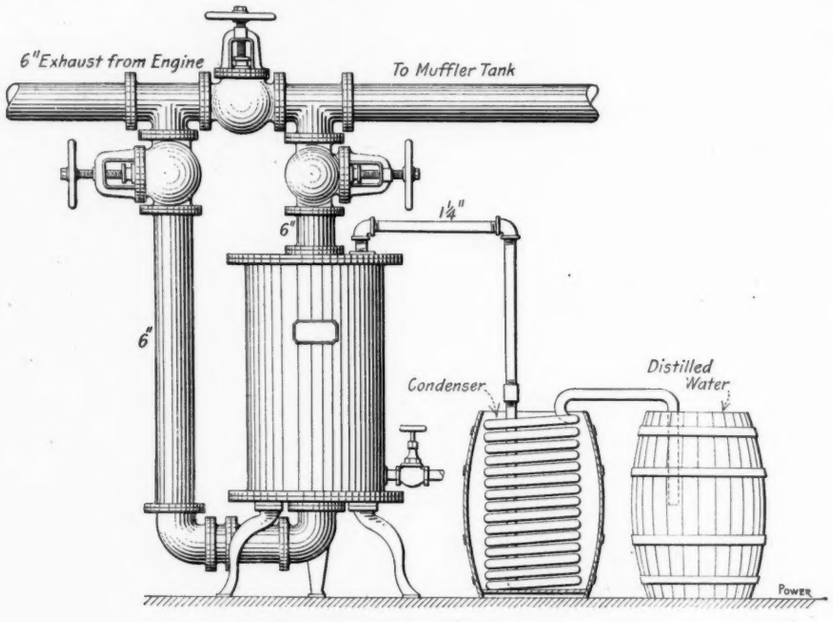
I suggest that he get a cast-iron closed heater of about 75 horsepower, also a set of gages and glass, and attach them to the heater so as to indicate the water level. He should bypass the exhaust line of the engine he uses most and regulate the feed water to the heater either by hand or by float-valve control. The heater should have a 1¼-inch outlet without a valve. A coil of a size to fit into a barrel of water to act as a condenser should be obtained and both ends carried up to the top of the barrel, one end connecting to the bypass pipe, the other leading to another barrel alongside the first.

This arrangement will provide all of the distilled water required at a total cost, including labor, of $150. About five barrels of 40 gallons each will be required per week and it would only be necessary to operate the outfit about one day in the week to obtain all the water needed. In case a smaller outfit is wanted to operate continuously, a 25-horsepower heater connected on the line will be satisfactory and will be much cheaper.

The water obtained in this way is pure and the cast-iron heater will last for many years. The bent coil and all the piping should be of copper or brass, as distilled water is very hard on iron or steel pipe. The diagram shows the manner of piping the outfit.

D. L. FAGNAN.

New York City.



DISTILLED-WATER APPARATUS

Central Station Sales Methods

In the October 24 issue, R. L. Ellis, under the caption "Why the Central Station Catches Isolated Plant Business," states that central-station solicitors do not deliberately mislead their prospective customers.

I beg to differ with him; there are many instances where, either wilfully or through erroneous ideas of what is legitimate business, misleading information is given to the prospective customer.

In POWER of February 14, 1911, under the head of "Central Station versus Factory Plant," I called attention to two instances which came to my notice. In 1911, is an article by a Mr. Fletcher, giving a report furnished by a central station which is glaringly at fault, showing considerable possibilities in other directions than in the installation of central-station power. In the *Electrical World* of July, a Mr. Perry gives a report which when carefully analyzed shows that it is distinctly unwise to install central-station power and that far greater economies can be obtained at less expense by taking proper care of the plant. In the American Institute of Electrical Engineers *Transactions* there are articles by Messrs. Hibner and Parker, bringing up numerous ideas, the principal one of which is the profit ratio, a justification of which factor has as yet not been brought forward.

These articles in themselves show that the central-station advocates are not always fair in placing their arguments before prospective customers. I have had frequent conversations with other engineers since the matter of central-station versus isolated-plant power came up, and they have in almost every case made the statement that the central-station solicitors as a rule overestimate the cost of power in the industrial or isolated plant, and underestimate the cost of power as it will actually be furnished by the central station.

Little or no care seems to be taken in the type of motors or the installation of motors recommended by the central station, the main object being to get central-station power into the factory plant. The only excuse I can see is the apparent belief that, once having installed central-station power and expended the money necessary to get it in, they feel that the owners will hardly consider wasting this money to take it out.

It is quite true, as stated by Mr. Ellis, that it is not the duty of the salesman of the central station to take care of the isolated plant and show its owners what they can do to improve their plant in other means rather than install the central-station power; but it is equally true that the central-station solicitor should not make misleading and false statements, nor should he try to do the engineering for the prospective customer. If there is any question in the mind of the owner, the central-station man should put it up to some reliable man, either the engineer of the prospective customer if the engineer is capable of handling it, or recommend some unbiased man to the purchaser, so that the work will be carefully and accurately done.

If the central stations get their business under false pretenses and the purchaser finds it out, he will spread this report broadcast and seriously handicap the central station in getting future business.

HENRY D. JACKSON.

New York City.

Engineers' Wages

The first-page article which appears in the October 31 issue is particularly strong and suggestive.

The picture of the steamfitter "doing" a job, and the intelligent-looking individual directing the other how and what to do, speaks volumes. But no one would for a moment suppose that the man on his feet could actually be getting less pay for what he does than the man on his knees gets for what the other tells him to do, if he were not familiar with the inside facts. If the onlooker is familiar with actual facts and conditions, then, of course, the picture does not represent the "eternal fitness of things," but rather "the incongruity of things."

That article and its illustration should set not only the employers of engineers to thinking, but the engineers themselves, for they have been patiently waiting and hoping to come into their just inheritance for a long time.

It is true that comparatively few have had their patience rewarded and their hopes realized, but the great majority of operating engineers all over the country are not much better in surrounding conditions than they were 25 years ago. And this in spite of the fact that many of them have learned more and are better equipped mechanically and educationally than ever they were before.

CHARLES J. MASON.

Scranton, Penn.

I read the foreword in the October 31 issue with a great depth of appreciation and satisfaction because every word as set forth therein is strictly true, and in keeping with the situation at the present time.

It is true the operating engineer has been laboring for years to make for himself a place that will be a credit to him, and put him in a position of respect and bring him a reward commensurate with what he really knows and does. This he has not realized, and when the steamfitter or machinist or plumber or electrician or bricklayer or, in fact, a member of any of the allied trades comes in to do a job for him, and the bill is sent from the office for his approval, it sets him to wondering what it all means.

A most peculiar fact is that sometimes when a capable engineer grows tired of things to the extent that he quits the job, the employer seems willing to labor along under the most adverse conditions for weeks and months, losing money every day to an amount far in excess of the small difference in salary asked for by the engineer, when a few words of inducement would have permanently adjusted the whole matter and put an end to the costly annoyances thrust upon the employer and apparently borne with such ease.

There must be a solution somewhere to this situation, and it strikes me that the foreword under discussion should awaken both the employer and the engineer.

JAMES A. ORR.

Elizabethport, N. J.

Loose Crank Pin

Referring to Mr. Hawkins' discussion in the October 24 issue of my letter in a previous issue concerning a centrifugal oiler which unscrewed from a loose crank pin, I will say that the engine was a left-hand one running over.

The ball on the end of this centrifugal oiler did not leave the horizontal oil pipe until the oiler dropped from the pin; therefore the pin must have turned in the disk until it screwed off of the oiler; to do this it must have turned in the disk in the same direction as the crank shaft. My assistant was feeling of the crank-pin brasses when the centrifugal oiler dropped the third time. At first I thought that the pin held in the crank-pin brasses while turning in the disk, but I had to give up that idea as this would cause the pin to turn in a direction that would screw it onto the end of the centrifugal oiler. I have since come to the following conclusion:

When the bead at the end of the pin was chipped off, the pin was so loose in the disk that it could be pushed out with a hammer handle. Now, assume that there was a little lost motion in the brasses. As the engine near the inside dead center before the lost motion in the brasses is taken up by the compression or the admission of steam, the weight of a part of the connecting rod acts downward on the top of the pin while the latter is traveling upward. In this position, therefore, the friction due to the weight of the end of the connecting rod will cause the pin to rotate over to the right when the lost motion is taken up.

As the pin nears the outer dead center, before the lost motion is taken up by compression at this end, if the conditions here were the same as in the other case, the pin would be rotated back to its first position. But the conditions are not the same.

The weight of the end of the connecting rod acts downward as before, but the pin is also traveling downward, and as the pin is moving about 15 feet per second it is running away from the weight of the connecting rod.

Under these conditions, when the lost motion is taken up at this end, the pin would still tend to rotate over to the right. I do not think that the friction of the pin on the lower side of the brasses will be great enough to cause the pin to rotate on this dead center, but it certainly will not lose what it gained on the inside dead center.

This rotation of the pin on the inside dead center would be but a small fraction of an inch each time, but it would eventually turn the pin enough to screw off the threads on the oiler. These were right-hand threads.

L. A. FITTS.

West Fitchburg, Mass.

Value of CO_2 Recorder

I have read with interest the discussion under the above heading. The main issue, I think, lies with the determination of CO_2 itself. Is the knowledge of the percentage of CO_2 in the flue gas of any value? The foundation of all the theories on flue gas is the fact that, assuming the temperature to remain constant, the loss of heat in the waste gases decreases with the increase of the percentage of CO_2. The only doubt to be raised is whether the temperature will rise with the CO_2. At some tests made by the Government at St. Louis in 1906 it was found that the temperature of the stack rose with the rise of temperature in the combustion chamber. Now as the combustion chamber is hotter with higher CO_2 it follows that with higher CO_2 higher flue temperature may be expected. I have not heard of this result being confirmed or disproved since 1906. Even if this is true, there must be an economical point at which to carry the CO_2 in order to get a minimum loss up the chimney. As to CO and unconsumed hydrocarbons, there must also be some economical point at which to carry the CO_2 so as to get the losses due to these down to the minimum. Now, if one has the complete analysis of a sample of flue gas and its temperature, he can calculate fairly accurately the losses up the chimney provided the sample is a true one.

When the percentage of CO_2 is high it is expected that a heavy or a close, even fire, and a tight setting will be found; in other words, a minimum of air leakage. When the amount of CO_2 is low, a dirty fire, bare spots on the grate, leaks in the boiler setting, etc., will be found. When the quantity of CO_2 is low the losses up the chimney are high, but it does not follow that when the percentage of CO_2 is high that the chimney losses are correspondingly low. It is this last idea that misleads most people in their estimation of the value of the CO_2 determination.

Now as to the CO_2 recorder. First, many object to the fact that it is next to impossible to get an average sample

of the gas from the uptake. A large number of schemes have been suggested, but if a single pipe is employed going to about the center of the uptake, the sample will not be far from the average.

As to the determinations: Some types of machines give a continuous record, others make analyses at intervals of two minutes or more. With an Orsat a man could not make a determination every 15 minutes very long. All personal errors are eliminated by the machine. There is no toilsome crawling over boilers or behind boilers to get the gas sample. I would say that if an Orsat were used, one or two determinations from each boiler a day are all that could be counted on and these are worth very little. The cost of a CO_2 machine would not exceed $100 per boiler and if a man is employed especially to get gas tests with an Orsat, his wages would soon pay for the machine, not to speak of the enormous difference in the service in favor of the machine. Supposing the machine takes 15 per cent. of its cost for repairs, etc., per year, the intelligent use of the machine would probably save this in a week. If no saving could be effected, it would be worth $15 per boiler per year to know that conditions were somewhere near right. That much could be saved by preventing an outlay of money for unnecessary things advised by unscrupulous people wishing to take advantage of one's ignorance of actual conditions.

I have known fuel experts to make a gas analysis with an Orsat at the rear of the boiler and then later (at least 15 or 20 minutes) take another at the exit of the economizer, figuring the air leakage from the difference in the CO_2. Now in that time the gas can change within very wide limits. In one case the CO_2 was higher back of the economizer than in front of it, which is absurd; nevertheless, these figures were turned in and great stress was laid in the report on air leaks. The management received them in good faith, assuming them to be absolutely correct.

If a CO_2 machine and a recording pyrometer are installed I believe, by a little experimenting with the dampers and the fire, together with careful thinking, great savings in fuel could be made. However, if the percentage of CO_2 is going to be taken as proportional to efficiency without any other consideration, the CO_2 machine will not be a success. There is too much tendency to assume that raising the CO_2 a slight percentage has made a big saving. If properly cared for and intelligently used, a CO_2 machine, especially in connection with a recording pyrometer, is a very valuable accessory in the boiler house and in many cases would quickly pay for itself and keep on saving money at the same rate.

JAMES E. STEELY.

Covington, Va.

Cylinder Oil Tested for Actual Service

In his article "Cylinder Oil Tested for Actual Service," H. B. Lange, in the November 7 issue, does not, to my mind, prove that 3 pints of cylinder oil were necessary to properly lubricate the cylinder and valves of the engine under discussion, except under the operating conditions described; for, if the condition of the crank-end exhaust valve were changed, I believe it would be possible to reduce the amount of cylinder oil used to at least 2 pints. I presume that the engine mentioned is of the four-valve nonreleasing-gear type, which usually is equipped with two eccentrics.

Mr. Lange says that after the test run of 10 hours, when 1.948 pints of cylinder oil were used, the crank-end exhaust valve was removed and showed two distinct spots of wear which were not there before the run. My deductions are that the two spots showing wear are high spots on the valve which are sustaining a much larger portion of the pressure of the valve on the seat, due to the pressure of the steam and the weight of the valve. Assuming that the travel of the exhaust valve varies with the load, and that the lighter load is carried longer than the heavier, the valve would make the short stroke oftener than the long and the high spots may have worn grooves in the valve seat which allow an even distribution of the load on the valve during light load.

I believe, if this valve is fitted to its seat, that the cylinder oil used may be considerably reduced without any further trouble.

A. K. VRADENBURGH.

Albany, N. Y.

The Loose Leaf Book Habit

In the course of many visits to power plants on a recent 9000-mile trip around the country, it was most interesting to note the remarkable differences in practice which are to be found among operating engineers. To take a single point as an example, nothing showed the individuality of the men holding responsible positions in this field better than the way in which their station data and records were kept. Of course, it is clear enough that no single system of keeping track of installation and service details will meet the requirements of all types of plants, but that some system should be scrupulously maintained was one of the most important lessons of the whole journey.

It may be a little late in the day to start a monologue on the subject of records of station equipment and operation, especially to the man who has been running a system of this kind for many years past. But if POWER readers could have gone on this trip and seen the need of such methodical work in more plants than I would like to count, there would be no complaint because reference has again been made to a rather threadbare topic.

The men who are handling their plants in the most broad-gage manner are the ones who are never at a loss to answer reasonable questions concerning the capacities and sizes of their equipment; who can turn at an instant to the performance of the station at any hour of the day for months past; who save time in ordering supplies and spare parts through reference to carefully prepared lists of material and fittings gathered from actual experience and tabulated either in inexpensive filing folders or neat loose-leaf books.

Still, there is room for improvement, particularly in the direction of furnishing operating engineers with complete sets of drawings of their plants and equipment arrangements, when such information has been prepared for use by the designing department. It is surprising how much good is accomplished by the simple scheme of filing blue-printed station-load curves in, say, 8x10-inch sheets perforated at the edges for insertion in a loose-leaf book on a time basis, when the demand arises for the presentation of data bearing upon outputs.

In one plant visited, the engineer in charge had supervision over several large and small hydroelectric generating plants, one or two steam stations and a score or more of substations. The keeping of data bearing upon the daily performance of all this equipment was so important on this system that a clerk was detailed to keep special watch of the work. The chief engineer, however, maintained in his office a set of loose-leaf books for each substation and generating plant, and as these were filed for individual portions of the system according to dates, it was possible within a few seconds to determine the load upon the system at any important point and at any day and hour for months.

The scheme was of the greatest assistance in determining the fitness of the existing equipment to meet the demands of the service, and when the question of extensions came up, with its added responsibilities for the operating force and tendency toward increased salaries resulting from the larger values placed in the hands of the men on shifts, the loose-leaf data sheets of loads were important factors in avoiding delayed plans for enlarged installations.

H. S. KNOWLTON.

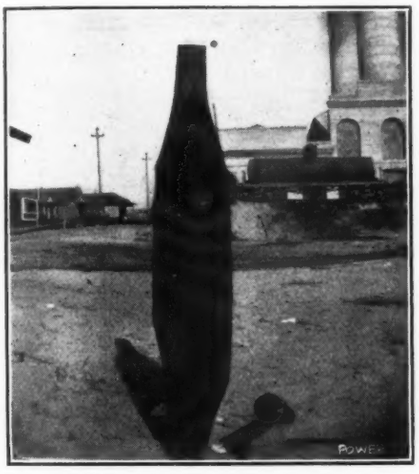
Newton, Mass.

The Institute of Operating Engineers has been instrumental in securing nine positions at salaries from $520 to $2080 for its members.

Boiler Tube Failure

The boiler-tube failure shown in the accompanying illustration occurred during a test, made some time ago, upon a Babcock & Wilcox boiler at the Redondo, Cal., power plant of the Pacific Light and Power Company. The tube was made of No. 10 gage lap-welded charcoal iron, 4 inches in diameter, and failed under a steam pressure of 185 pounds. The explosion fortunately resulted in no disaster other than placing the boiler out of service. The break is remarkable in size, being 5 feet long from tip to tip; at the central portion, as will be noticed, the tube is as flat as a board.

The boiler has a rating of 604 horsepower, and consists of 21 sections of



BREAK IN TUBE 5 FEET LONG

fourteen 4-inch tubes 18 feet long. It is designed for 200 pounds working pressure, 175 pounds being carried under operating conditions. The unit is equipped with a forged-steel superheater, which gives about 100 degrees Fahrenheit at the boiler nozzle. Ordinarily, 4-inch hot-drawn seamless steel tubes are installed, the charcoal-iron sections used at the time of failure being primarily for the purpose of testing what they would bear in actual service. The accompanying photograph was taken by Orie Brian, formerly in charge of the boiler room at the plant.

Fatal Marine Boiler Explosion

The steamer "Diamond" was blown to pieces by a boiler explosion in the Ohio river near Davis Island dam, about five miles below Pittsburg, Penn., on December 2. Five men, including the captain, were killed and two were severely injured. The engineer and two firemen were among the killed. The "Diamond" sank immediately in midstream.

The cause of the explosion is unknown. No trouble had been experienced with the boilers. They had been inspected on June 23, 1911, and a certificate of inspection one year from date had been granted by Government inspectors.

Owned by the Diamond Coal Company and operated as a towboat for a line of coal barges, the boat had towed some coal barges to East Liverpool and was returning to Pittsburg when the explosion occurred.

President Meier's Address at Annual Meeting of the A. S. M. E.

The address of Colonel Meier, retiring president of the American Society of Mechanical Engineers, at the annual meeting on December 5, traced the rise of the engineering profession from a very meager beginning to the important place it now holds. His remarks were in part as follows:

"A century ago the distinction between the civil and the military engineer sufficed, but later it became necessary to differentiate in turn the mechanical and the electrical engineer, while quite recently upward of a hundred specialties were enumerated in the attempt to define the activities of the profession.

"Slowly but surely the superstitions and traditions which so long encumbered social life and hampered free development, are exposed and annihilated by the altruistic labors of men who give their life to science. It is the duty of the engineer to receive these discoveries and apply them to the solution of the practical problems of life.

"Those great road and bridge builders, the Romans, produced military engineers, but theirs were mainly static problems; and even their much vaunted aqueducts show lack of coöperation between science and practice. They were carried over valleys on costly structures inviting destruction at the hands of the enemy. With their excellent cement and their knowledge that water always seeks its level, their engineers might have built subterranean conduits.

"Early in the nineteenth century the scientific method came into vogue, and henceforth problems were studied and defined before their solution was attempted, and more intellectual labor was expended in ascertaining facts than in reasoning about them. Thus the union between the mechanic and artificer and the student of nature's laws became possible and permanent, and engineering developed from an art into a profession.

"The engineer is a devout believer in natural laws; he knows that they are immutable and permit no exceptions; he needs no supreme court to define them as reasonable—they are the very foundation of the universe, and reason itself owes its existence to them. Every infraction of them brings its own punishment. To men thus trained, the future of the race is to be confided.

"The enlightened man loves his work and finds in it his supreme incentive. To a Copernicus or a Newton, a Watt or a Corliss, an Ericsson or a Fritz, an Edison or a Steinmetz, the ransom of a king would seem trivial compared with the satisfaction of knowing that he has given to his fellow men an achievement which marks a forward step in the evolution toward a race of rational beings.

"The unrest in the modern world has its basis in an underlying sense of injustice. The growing sense of community of interest, the knowledge of our dependence on each other, the ever expanding humanitarianism, are all founded on scientific facts, and are becoming world movements.

"The engineer is responsible for the vast increase in appliances to meet every demand of that most voracious of living beings, man. The mass of mankind needs to be educated to understand and use them properly. He is in honor bound to supply this education; and as the crude dangers and fears of the earlier centuries vanished, so the prejudices and superstitions of the dark ages are being swept away."

Doctor Humphreys President of A. S. M. E.

Dr. Alexander C. Humphreys, president of Stevens Institute and the foremost gas-plant engineer in this country, has been installed as president of the

DR. ALEXANDER C. HUMPHREYS

American Society of Mechanical Engineers.

Colonel Meier, the retiring president, in introducing Doctor Humphreys, paid tribute to his fitness for this new position and briefly sketched his early life and struggles in acquiring an education.

In the face of circumstances which would have seemed insurmountable to the average man, Mr. Humphreys gradu-

ated from Stevens Institute with the class of 1881, having accomplished for the most part at night, after a day's work had already been done elsewhere, what normal students fresh from advanced schooling accomplish only by unremitting application of all their working time.

Soon after graduation, Mr. Humphreys became chief engineer of the Pintsch Lighting Company, of New York. In 1885, he was made superintendent of construction for the United Gas Improvement Company, and shortly afterward took the position of general superintendent, with headquarters in Philadelphia.

Eventually he assumed control of the entire commercial management of all the company's works, including the Welsbach Incandescent Lighting Company, which at that time was a subsidiary of the U. G. I.

In August, 1894, Mr. Humphreys retired from his official relations with the United Gas Improvement Company to establish the firm of Humphreys & Glasgow, of New York, recently succeeded by the firm of Humphreys & Miller, Inc., of which he is president.

In June, 1902, Mr. Humphreys was elected president of Stevens Institute of Technology, by unanimous vote of the trustees. In 1903, the degree of doctor of science was conferred upon him by the University of Pennsylvania, and the degree of doctor of laws by Columbia University. New York University also conferred the degree of doctor of laws in 1906, and Princeton University in 1907.

Doctor Humphreys has been the chief executive officer of more than fifty-five gas and electric-light companies, and is now president of the Stevens Institute of Technology, Humphreys & Miller, Inc., gas engineers, and the Buffalo Gas Company. He is a director in the Equitable Life Assurance Society, a member of its executive committee, and a trustee member of the executive committee of the Carnegie Foundation for the Advancement of Teaching. He is a member of almost every prominent technical society in this country; of the Delta Tau Delta Fraternity, and of many clubs and philanthropic societies, to all of which he gives liberally of his time and strength.

In assuming the duties of president of the American Society of Mechanical Engineers, he is adding greatly to his present responsibilities, and yet such is his capacity for service for others that the affairs of the society will be in as sure and safe hands as ever before, and the society is fortunate indeed in having him for its president.

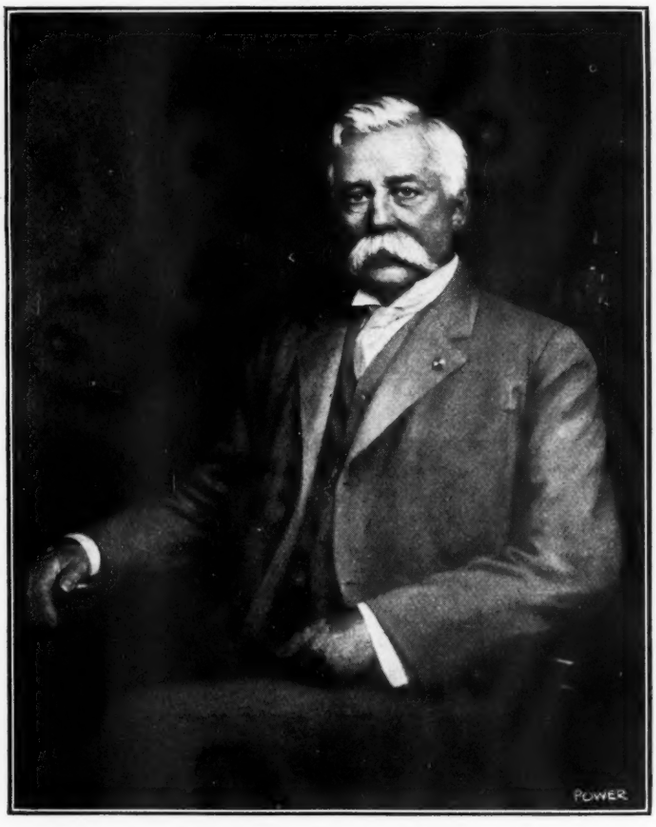
In accepting the presidency, Doctor Humphreys referred to the fact that the society was organized at Stevens Institute and that Doctor Thurston, then professor of mechanical engineering at the Institute, was elected its first president. In acknowledging the honor conferred upon him he referred to the heavy responsibility involved in accepting the office, especially in view of the dividing and subdividing of the engineering profession into so many specialties, and in this connection he referred to the movement recently inaugurated in the society by the appointment of subcommittees of the meetings committee to provide studies and papers on the many industries which might be considered as related to the profession of mechanical engineering, there having been about forty such committees suggested with, no doubt, more to come.

While recognizing the need for this closer and closer specializing in engineering and industrial management, he deprecated the multiplication of societies and expressed the hope that means would be found to keep the direction of this movement within the society while providing the fuller measure of home rule for each section consistent with an efficient system of coöperation. To develop a system of such wide scope would require great good judgment and tact on the part of all concerned, for the opportunities for disagreement and friction must, for safety, be at once recognized. Here would be an opportunity for the engineers of the country to show their capacity for effective service in the community at a time when such service is needed as never before.

He also drew attention to the fact that the extension of the society's activities along the lines referred to would call for greatly increased financial support.

Colonel Meier's Portrait for the A. S. M. E.

As the seventieth birthday of Col. Edward D. Meier, retiring president of the American Society of Mechanical Engineers, occurred on Memorial day, during the Pittsburg meeting of the society, a large number of the members united in a subscription and presented to him an illuminated address of congratulation, as previously reported in these columns, and also asked his consent to give sittings for a portrait. This portrait has just been finished and will be on exhibition in the rooms of the society at its annual meeting in the Engineering Societies building, New York, December 5 to 8. The portrait represents him in a pearl-gray suit and sitting in a rather easy position.



PORTRAIT OF COL. E. D. MEIER

The artist was Daniel J. Strain, vice-president of the Boston Art club, whose studio has been in Boston for a number of years. Mr. Strain is one of the leading portrait artists, and among his works are portraits of many of the leading men of the East. He was born in New Hampshire and studied for eight years in Paris. His works have been admitted to the Salon on three different years and he is a frequent exhibitor at art exhibits in this country.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

We have been asked what good came of the convention of advertising men in Boston.

Of course, there were many tunes played, but the note that was heard above all others was honesty.

Honest, straightforward advertising has the right of way.

Over 2000 business men—buyers and sellers—from all over this continent and England, so declared themselves.

They demanded that everyone who wants the respect of other sellers, who wants the business of the buying public, must play fair.

That's the handwriting on the wall.

Selling practices that have heretofore been passed over in silence, if not condoned, must stop.

The fraudulent, lying advertiser is an outlaw and will be so looked on.

The crook will find his doom under the steam roller of progress.

One speaker said:

"For two years and more we have steadfastly held to a purpose. That purpose is to educate the advertisers of this country that there is but one kind of advertising that will be permanently profitable and that is honest, truthful advertising. And at the same time we are endeavoring to teach the American people the believableness of advertising and forever stamp out the stigma of untruth, which is so often applied to advertising, and banish from the minds of the people the thought that an advertisement of a corporation or firm is in any degree less reliable than its signed statement."

Another result is a movement on foot to have a national law for the repression of dishonest advertising.

Mayor Gaynor, of New York, on November 10, wrote to the editor of *Printer's Ink* referring to this:

"I have read the proposed statute which you inclose to me and I can see no reason why it should not be adopted. To publish false and misleading statements in advertisements ought to be a criminal offense. Of course the business of advertising is now reduced almost to a science and the great majority of advertisements are truthful."

That's the kind of advertising in these columns. No false statements can appear if we know it.

Which is another reason why it's safest to buy advertised goods.